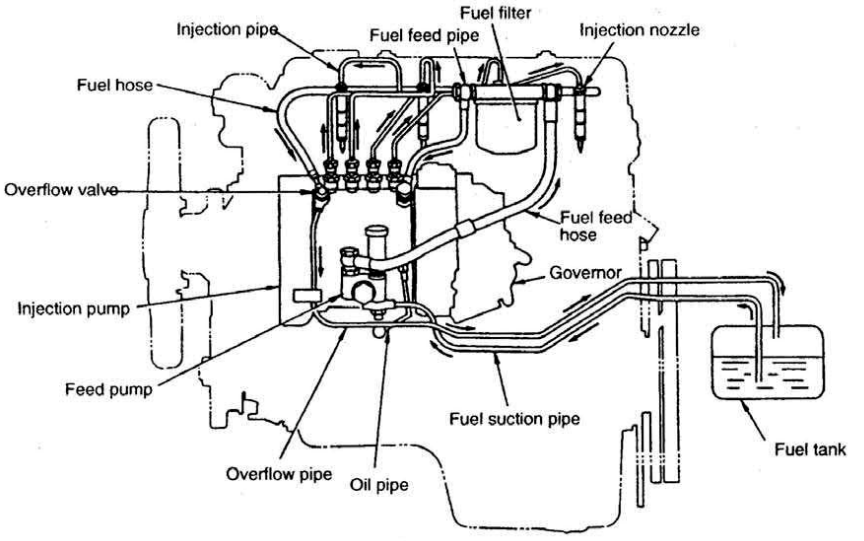
1. GENERAL

The fuel system consists of the injection pump assembly(injection pump proper, governor, feed pump), auto timer, fuel filter, injection nozzle, injection pipe, and other parts.

Fuel is fed from the fuel tank through suction pipe to the feed pump of the injection pump assembly, and then to the fuel filter, injection pump, and injection nozzle. The excess fuel is returned from the injection pump to fuel tank(direct injection type engine) or from the injection nozzle to the fuel tank(swirl chamber type engine).



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(1) A-type Injection Pump

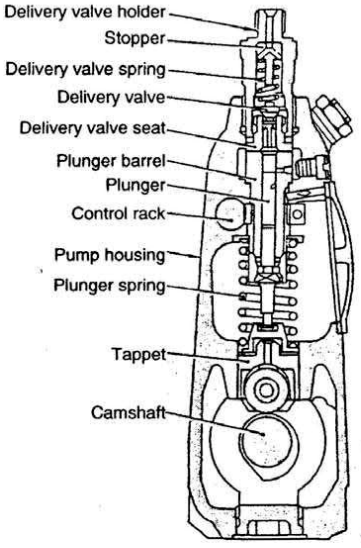
The injection pump is a device which forces fuel to the injection nozzle and has a mechanism for increasing or decreasing the pressure feed quantity according to the engine load and speed.

The injection pump is constructed as shown in illustration at right.

It has one plunger and delivery valve for each cylinder.

The plunger, pushed up by the camshaft and pushed back by the plunger spring, movers up and down through the plunger barrel on a predetermined stroke to feed fuel under pressure.

Both ends of the camshaft is supported by the taper roller bearings and is driven by the timing gear at 1/2 engine speed.



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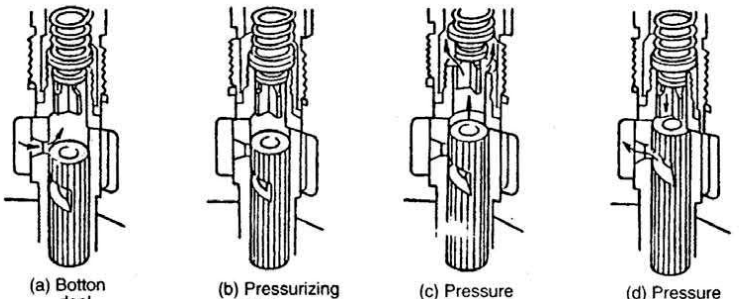
(a) Pressure feed of fuel

The plunger has an obliquely cut grove(lead) on its side as shown.

At the top of the plunger there is a hole which leads to the groove.

The plunger barrel has suction and discharge ports.

The fuel delivered to the injection pump is forced by the rotation of the camshaft or reciprocating motion of the plunger as shown below.



When the plunger is at the lowest position or bottom dead center(a), fuel flows through the suction and discharge ports into the plunger.

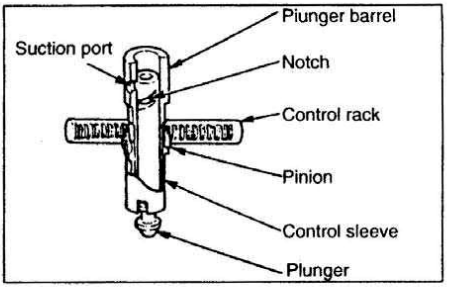
Rotation of the camshaft moves the plunger up. When the top surface of the plunger is lined up with the suction and discharge ports, application of pressure to fuel begins(b).

As the plunger moves up further(c), and the lead of the plunger meets with the suction and discharge ports, the high pressure fuel flows through the hole in the plunger and runs back from the lead to the suction and discharge port, and the pressure feed of fuel is completed(d).

The plunger stroke during which the fuel is fed under pressure is called the effective stroke.

(b) Injection amount control system

According to the engine load, the amount of injection is increased or reduced by turning the plunger a certain angle to change the position where the lead meets with the suction and discharge ports on the up stroke and increasing or reducing the effective stroke.



The control rack is coupled to the floating lever in the governor. If the control rack is moved to right or left by operation of the governor, the control sleeve in mesh with the rack is turned. Since the bottom of the control sleeve is in mesh with the bar of the plunger, the plunger turns with the control sleeve, so the effective stroke changes and the injection amount increases or decreases. The more the control rack is pulled toward the governor, the less the effective stroke and the less the injection amount.

Each plunger is in mesh with this single control rack and simultaneously turns the same amount.

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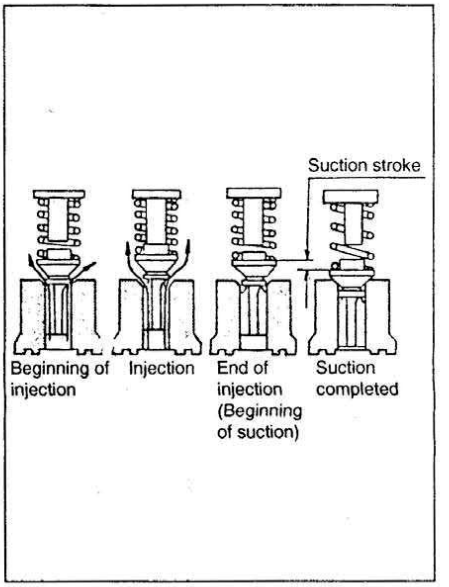
(c) Delivery valve

The delivery valve, provided on the top of the pump housing, performs the function of discharging the pressure in the injection pump.

The fuel compressed to a high pressure by the plunger pushes the delivery valve up and spouts out. If the pressure feed stroke of the plunger ends, the delivery valve is brought back to its original position by the pressure of the delivery valve spring to block the fuel path, thereby preventing counter flow of the fuel.

The delivery valve is brought down further until the seat surface is held tight. During that stroke the fuel is drawn back from above to instantly lower the residual pressure between the delivery valve and nozzle. The draw-back effect improves the end break of an injection from the nozzle and prevents after-injection dripping.

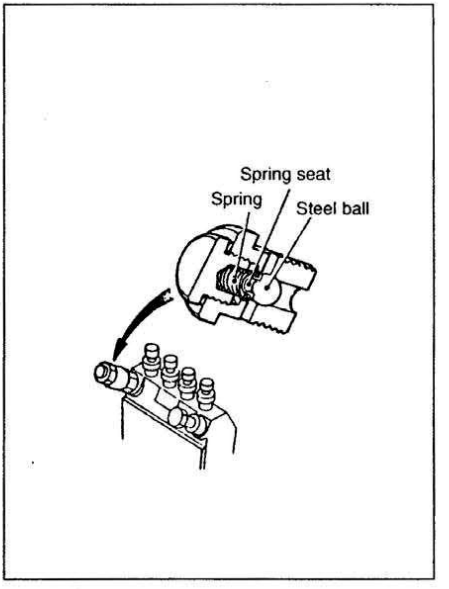
A delivery valve stopper is provided on the top of the delivery valve spring. The stopper limits the lift of the delivery valve and prevents valve surging during high speed rotation. In addition, it reduces the dead volume between the delivery valve and nozzle, thereby stabilizing the injection amount.



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(d) Overflow valve

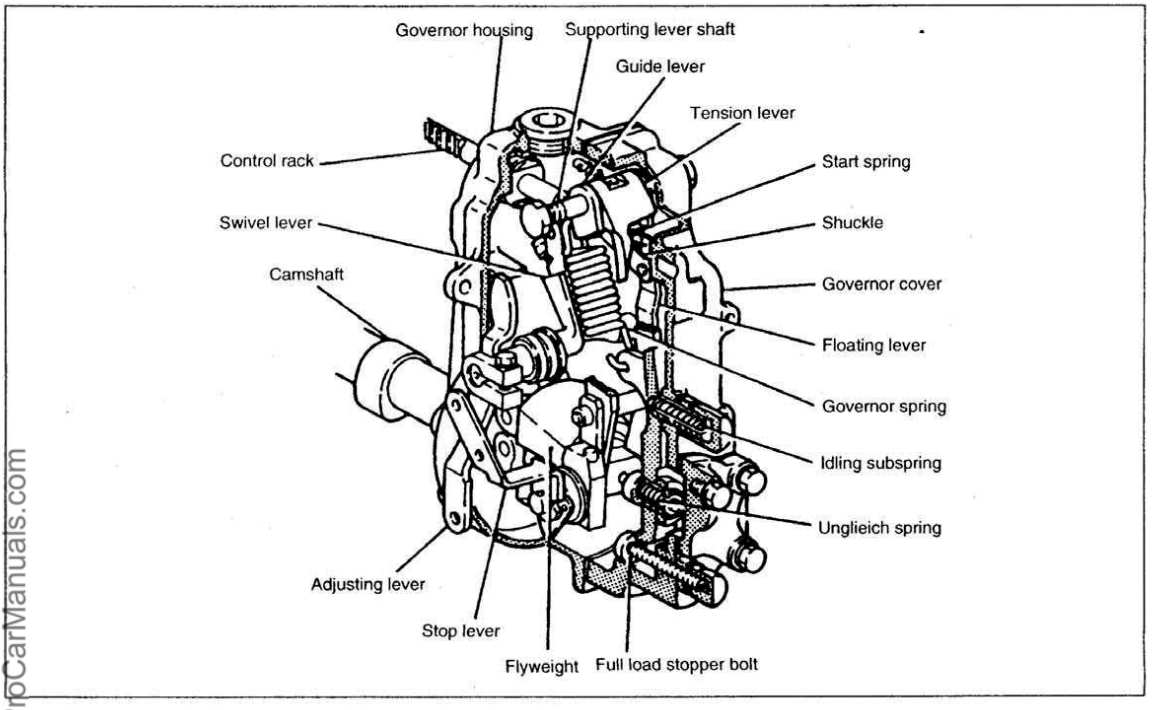
When the fuel pressure in the injection pump exceeds a set level, the steel ball in the overflow valve goes up to let the fuel flow out of the injection pump and return to the fuel tank, thereby stabilizing the fuel temperature and temperature distribution in the injection pump and maintaining the injection rate into each cylinder constant.



(2) Governor

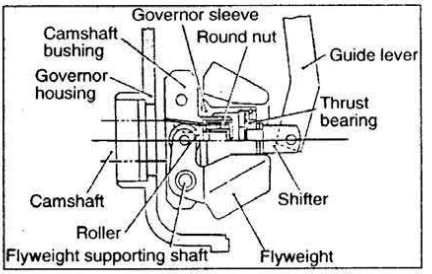
(a) RSV type governor

The RSV type governor is a centrifugal type all-speed governor coupled to the camshaft of the injection pump. The governor not only controls the maximum and minimum speeds but also automatically controls the engine speed at any intemediate speed position.



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The governor, as shown, consists of flyweights mounted to the injection pump camshaft. When the flyweights turning on the flyweight supporting shaft open outward, the roller mounted to the end of flyweigth arm pushes the end of the sleeve in the axial direction. The governor sleeve, being made integral with the shifter through a bearing, moves only in the axial direction.



The shifter, mounted to the guide lever hung on the supporting lever shaft of the governor cover, prevents rotation.

The floating lever is mounted to the middle of the guide lever by the shaft with the bottom end as the fulcrum, whereas the top of the lever is coupled through the shackle to the control rack.

The start spring, attached to the top end of the floating lever, always pulls the control rack in the direction that fuel is increased.

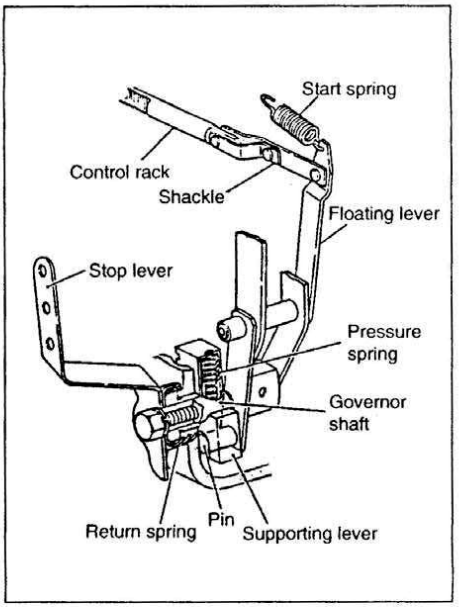
The turning shaft of the swivel lever is fitted into the bushing of the governor cover and its center is eccentric with respect to the mounting position of the governor spring installed to the tension lever. The governor spring is installed to the end of the swivel lever. When the governor spring receives tension, the bottom end of the tension lever touches the adjustable full-load stopper bolt.

When the angle of the adjusting lever is changed, the angle of the swivel lever is also changed and the tension of the governor spring changed. This is because the turning center of the swivel lever and the mounting position of the governor spring installed to the tension lever are accentric to each other as mentioned above.

An adjusting screw is also mounted to the swivel lever. Adjustment of the screw changes the tension of the governor spring, thereby making it possible to adjust the speed regulation.
An Ungleich spring is provided in the bottom portion of the tension lever. Adjust the tension of the spring by adding or removing shims.

An idling sub spring adjustable from outside is provided in the middle of the governor cover.
During idling, the spring always keeps in contact with the tension lever to maintain a constant idling speed.

The stop lever, mounted through the supporting lever to the bottom end of the floating lever, returns the control rack to the stop position with a slight pressure irrespective of the adjusting lever position.



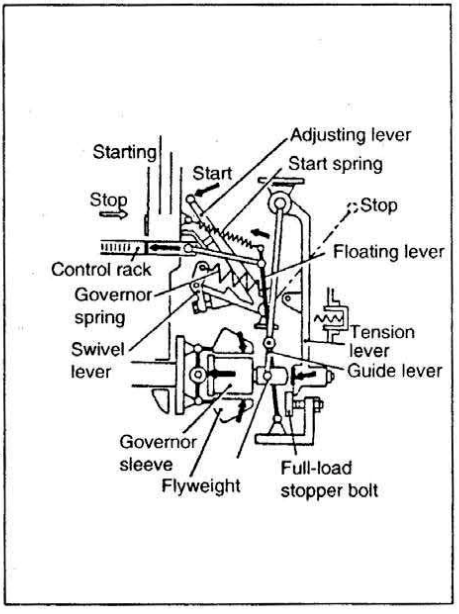
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1) Start of engine
When the adjusting lever is moved to the start position(until it touches the maximum speed stopper), the swivel lever which moves with the adjusting lever pulls the governor spring and moves the tension lever until it touches the full-load stopper bolt.

At that time, the flyweights are stationary, and the start spring with weak tension pulls the floating lever in the direction that fuel is increased.

At the same time, the shifter and governor sleeve push the flyweight roller to the left.

As the result, the tension lever and shifter are spaced that much aprat, and the corresponding amount of fuel is supercharged to facilitate starting.



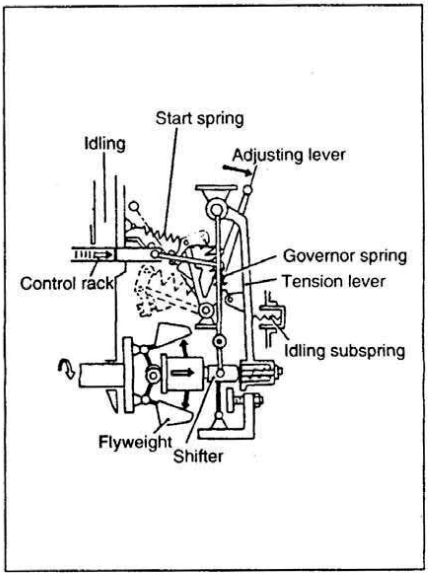
2) Idling control

Once the engine is started and the adjusting lever returned to the idling position, the tension of the governor spring is drastically reduced.

Now the flyweights can move outward even at a low speed, so the tension lever is pushed back until it touches the idling sub spring and places the control rack at the idling positing. In this state, the centrifugal force of the flyweight and the weak-state governor spring and idling sub spring achieve balance and maintain smooth idling.

When the speed falls, the centrifugal force decreases, the flyweights move inward, and the idling sub spring pushes the tension lever to the left and moves the control rack in the direction that fuel is increased.

If the speed falls radically, the start spring with weak tension acts and moves the control rack in the direction that fuel is increased to maintain the idling speed.

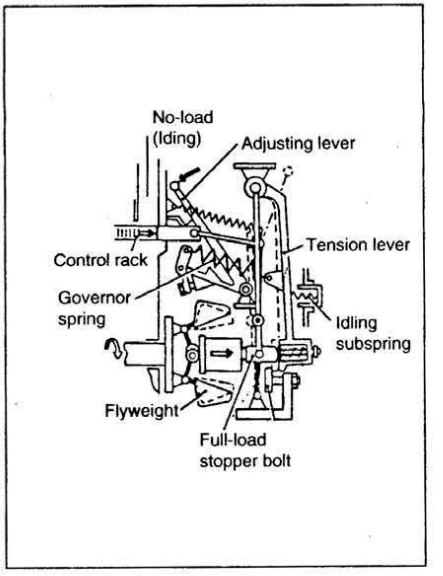


3) Maximum speed control

When the adjusting lever is moved to the full-load position, the tension of the governor spring is increased and pulls the tension lever until it touches the full-load stopper bolt.

When the engine exceeds the specified speed, the centrifugal force of flyweights becomes larger than the force of the governor spring pulling the tension lever. So the tension lever is moved to the right and moves the control rack in the direction that fuel is reduced, thereby preventing the engine from exceeding the specified speed.

If the speed further increases, the centrifugal force of flyweight increases and pushes the tension lever to the right and also compresses the idling sub spring to pull the control rack back to the no-load maximum speed position, thereby preventing over-speed operation of the engine.



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The RSV type governor controls the entire speed range from idling to maximum speed.
If load increases or decreases at a certain speed determined by the position of the adjusting lever, the governor automatically functions and maintains the engine speed constant at all times.

4) Ungleich operation

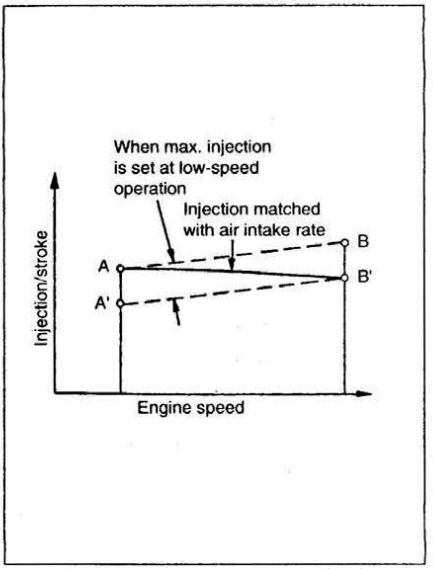
The Ungleich device controls fuel injection in such a way as to match the engine performance(the required injection varies with engine speed.)

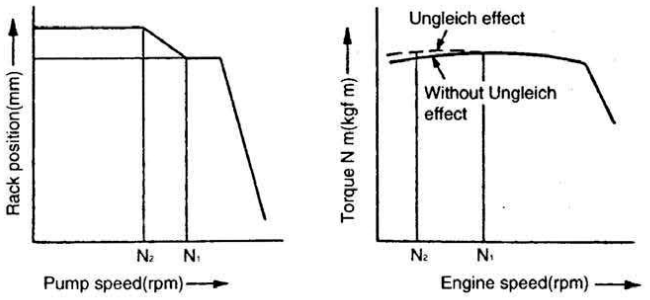
The air intake rate of the engine falls as the engine speed increases. The injection pump, on the other hand, increases the per-stroke injection as the speed increases, even with the control rack at the same position.

Therefore, if full load is set at point A to derive enough output at low speeds, the injection will reach B as the speed increases, and the engine will produce black smoke.

If full load is set at point B' to prevent black smoke, the low speed injection will come down to A', allowing combustion of more fuel.

So the Ungleich device accomplishes the function of setting full load at point A to derive the largest possible torque in the low speed range, and changing it to adjust the injection to point B' in the high speed range.

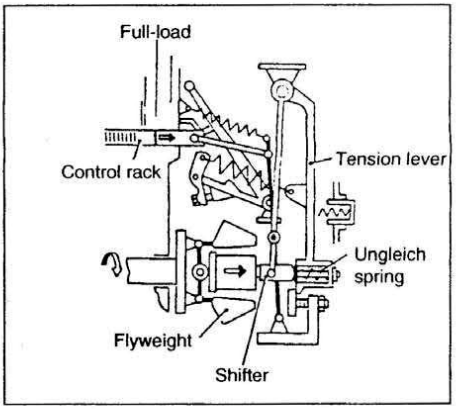




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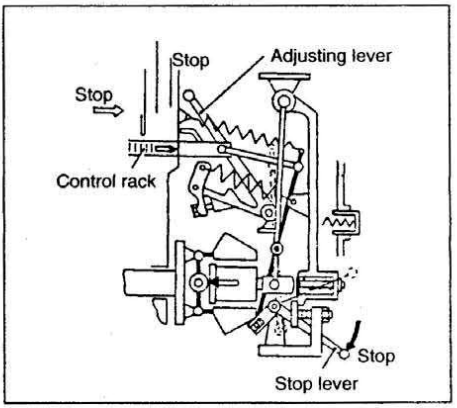
When the engine speed is low and the centrifugal force of flyweight smaller than the set tension of the Ungleich spring, the shifter is moved as much as the Ungleich stroke to the left, so the control rack moves in the direction that fuel is increased to increase the torque of the engine at low speeds.

As the engine speed increases, the centrifugal force of flyweight increases. If it becomes larger than the set tension of the Ungleich spring, the Ungleich spring is slowly compressed before the start of high speed control, and the control rack moves in the direction that fuel is reduced. The Ungleich stroke is completed at the position where the shifter directly touches the tension lever.



5) Stopping of engine

When the stop lever is moved to the stop position, the control rack is moved to the stop position to stop the engine regardless of the position of the adjusting lever.



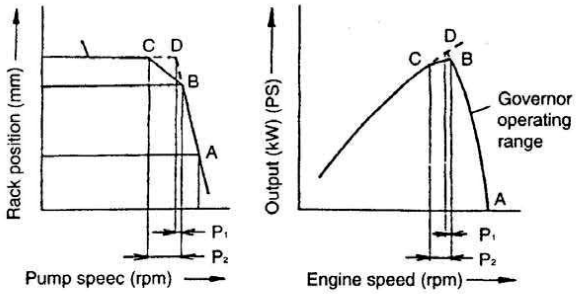
6) Operation of torque spring

Construction machinery engines are often subjected to a large load during operation, and reduced speeds often lead to stalls. To prevent this, a torque spring is provided.

When the adjusting lever is fixed in the lever set position, a sudden increase of load, if no torque spring is provided, will move the control rack along the B-D curve as the speed falls. The rotational displacement at the time may be expressed as P1.

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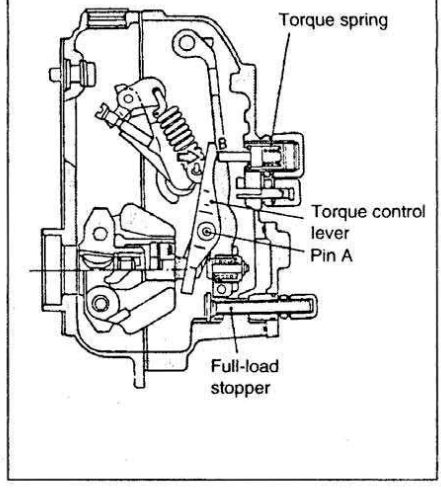
If a torque spring is provided, the control rack moves along B-C, and the rotational displacement at the time may be expressed as P_2. Therefore, large changes occur in P_2 and engine speed, and because of increased fuel injection, the engine torque increases, and large combustion noise warns the operator of the increased load, enabling him to take proper action to prevent stopping the engine.



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In an abrupt increase of load occurs when the engine is running at continuous rating, the engine speed falls. So the flyweights are moved inward and the tension lever pulled to left by the governor spring, causing the control rack to move in the direction that fuel is increased.

At the time, the tension lever pin pushes the bottom of the torque control lever, and the lever moves with the pin A as the fulcrum, whereas the portion B is pushed to right. As the result, the torque spring performs the function of reducing movement of the tension lever.

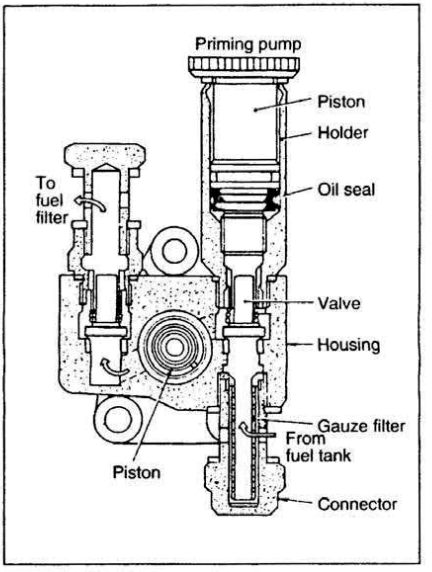


(3) Feed Pump

The feed pump is driven by the camshaft of the injection pump.

The priming pump makes it possible to manually lift fuel when the injection pump is stationary, so it can be used in bleeding the fuel system.

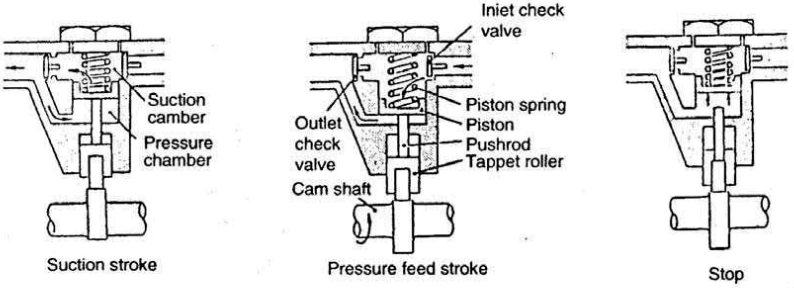
The gauze filter removes large particles of dust and dirt contained in the fuel lifted from the fuel tank to prevent clogging in the feed pump. Make sure the gauze filter is cleaned in gas oil at regular intervals.



The fuel is fed under pressure as described below. When the camshaft of the injection pump forces the push rod up, the fuel in the suction chamber is compressed and opens the outlet check valve. Most of the fuel forced out is drawn into the pressure chamber above the piston. When the cam, moved away by rotation of the camshaft, cases to push up, the piston is pushed back by the pressure of the piston spring and forces out the fuel from the pressure chamber and forces it into the fuel filter.

At the time, the outlet check valve simultaneously closes, and the inlet check valve opens, so the fuel is drawn into the suction chamber.

If the pressure in the pressure chamber exceeds specification, the piston cannot be brought back by the pressure of the piston spring and stops the pump function. So the pressure in the fuel filter is adjusted not to rise more than necessary.

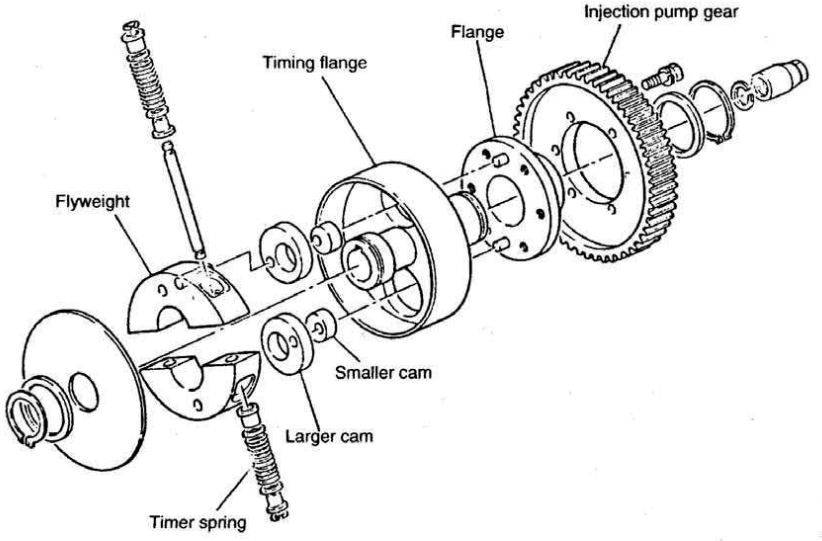


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(4) Automatic timer

(a) SCDM type timer(D4A)

The SCDM type auto timer, of a mechanical type, varies the fuel injection timing automatically according to engine speed. Attached to the injection pump camshaft with round nuts, the auto timer is driven by the injection pump gear from the idler gear.



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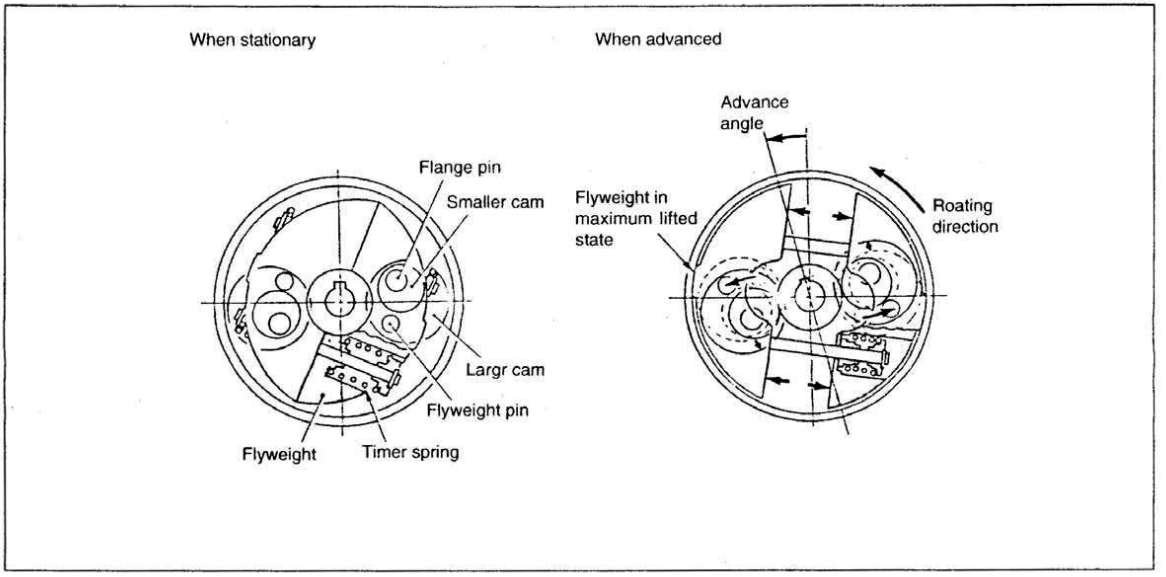
There are two pins opposing to each other press-fitted into the flange, to which the injection pump gear is attached. An eccentric smaller cam is installed on the pin, and mounted on the periphery of the smaller cam is a larger cam. The larger cams fit into the two holes in the timing flange, which causes the timing flange to turn as the flange rotates, thus dirving the injection pump.

The two flyweights are installed with a given tension by the timer springs. The pins press-fitted into the flyweights are inserted into the holes in the larger cams.

With the engine running at low speed, the flyweights are unable to lift because of the timer spring set tension.

When the centrifugal force of flyweights becomes greater as the engine speed goes up, it overcomes the timer spring set tension allowing the flyweights to lift. This causes the larger and smaller cams to move in the turning direction.

Since the larger cams are fitted into the holes in timing flange, the motion of the cams is imparted to the timing flange, thus providing an advance.

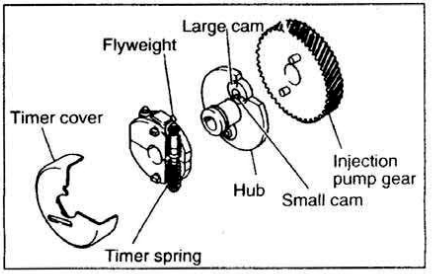


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(b) SBO type Automatic timer (D4DA)

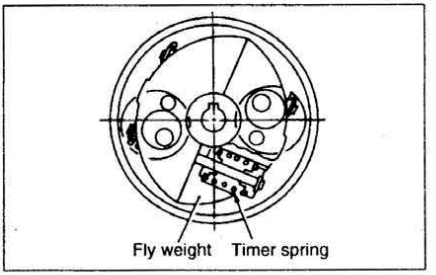
The automatic timer utilizes a mechanical arrangement to adjust the injection timing in accordance with the engine speed.

The automatic timer is mounted on the injection pump camshaft using a round nut. It is driven by the idler gear which is in engagement with the injection pump gear.



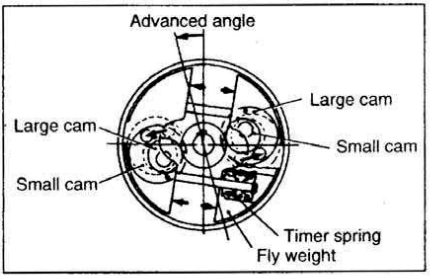
1) At standstill

Flyweight is forced to close by the tension of timer spring.



2) At operation

As the engine speed rises, the centrifugal force acting on flyweight increases, and when it overcomes the tension of the timer spring, the flyweight start to open. Therefore, the small cam and the large cam move in the direction of rotation. Since the large cam is fitted in the hole of hub, the movement of the large cam is transmitted to the hub, thus the injection timing being advanced.

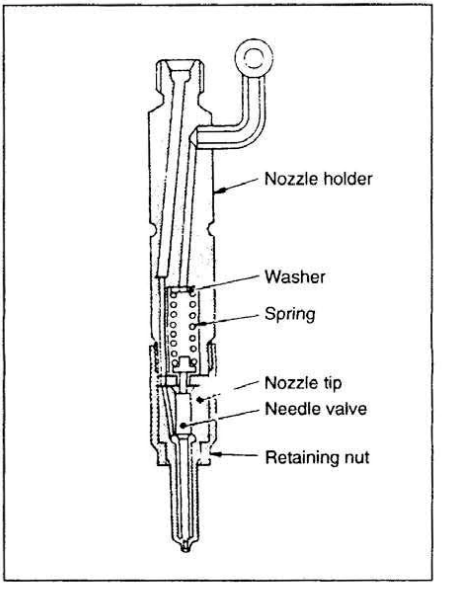


(5) Injection Nozzle

The injection nozzles are of the hole type and the throttle type.

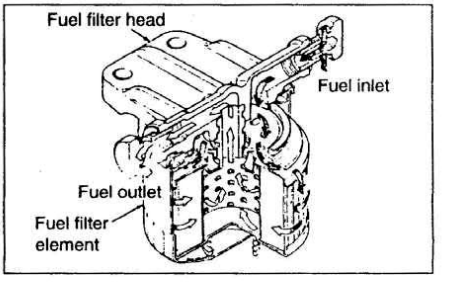
The fuel delivered from the injection pump enters the nozzle holder. When reaching the specified pressure valve, the fuel overcomes the spring force to push up the needle valve of the nozzle tip, spraying from the injection orifice at the end of the nozzle into cylinder(hole type).

The injection pressure can be adjusted by increasing or decreasing the number of washers in the spring.



(6) Fuel filter

The fuel filter is of the spin-on type designed for ease of element replacement. The element is made integral with the outer casing, the center of the casing is being threaded.



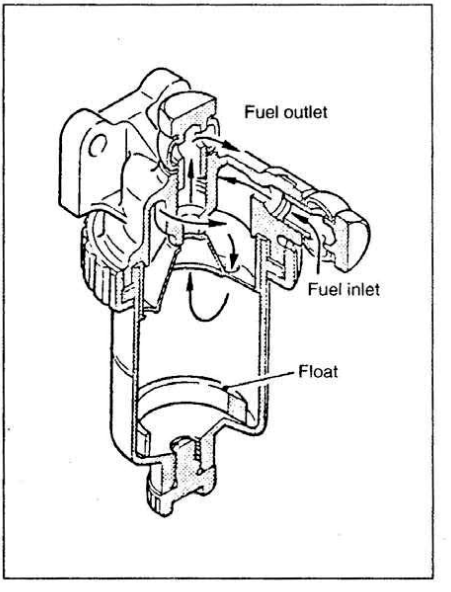
(7) Water Separator<Option>

The sedimenter type water separator separates gas oil and water centrifugally by taking advantage of their difference in specific gravity.

The fuel that has flowed in from the inlet connector is squeezed by the fuel path of the head to increase the flow velocity and spins.
The separated water is sedimented in the case, whereas the water-separated fuel is drawn through the fuel path in the center of the head into the feed pump.

The water separator sediments not only water but also mud components.

A red float goes up and down with the water level in the semitransparent case, marking it possible to visually check the water quantity.



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2. SPECIFICATIONS

Model		Specification		
		<D4AK>	<D4AN/AF>	<D4DA>
Injection pump proper	Type	BOSHC A	←	←
	Model	NP-PES4A90	ND-PES4A90	
Turning direction (As viewed from drived side)		Clockwise	←	
Plunger	Diameter	9mm	←	←
	Lead	R.H. single or two-step	R.H. single-step	←
Governor	Type	RSV, all speed mechanical minimum-maximum, mechanical	RSV, all speed mechanical	←
Feed pump	Model	NP-FP/KS22AC	ND-FP/KS22AC	
Auto-timer	Type	SCDM, mechanical (2,600 rpm or more)	←	SBO
Injection Nozzle	Type	Hole		←
	Model	NP-DLLA	ND-DLLA	
	No.of ofrifices	5	←	←
	Orifice diameter	0.28 or 0.30 mm	0.28 mm	
	Orifice angle	160	←	
	Injection pressure	17.7 MPa (180 kgf/cm²) or 21.6 MPa (220 kgf/cm²)	17.7 MPa (180 kgf/cm²)	
Fuel filter	Type	Spin-on, filter paper		
Water separator <Option>	Type	Sediment trap		

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3. SERVICE STANDARDS

3-1 Service shandard Table

Unit : mm

Description				Nominal value [Basic diameter]	Limit	Correction and remarks
Injection pump Proper	Overflow valve opening pressure			255 kPa(2.6 kgf/cm2)		
	Control rack sliding resistance (When not rotating)			1.5N (0.15 kgf) or less		
	Camshaft end play			0.02 to 0.06	0.1	Adjust or replace
	Backlash between control rack and pinion			0.15	0.3	Replace
	Tappet roller overall clearance				0.2	Replace
	Tappet to pump housing clearance			[24] 0.03 to 0.07	0.2	Replace
	Wear on lower spring seat surface in contract with plunger				0.2	Replace
	Plunger driving face to control sleeve clearance			0.02 to 0.08	0.12	Replace
	Control rack full stroke			21 or more		Adjust
	Prestroke			3.5 ± 0.05		Adjust
	Injection start interval			90° ± 30°		Adjust
	Tappet clearance			0.3 or more		Adjust
RSV governor	Governor housing end face to shifter distance	Nippondenso products(D4DA)		15 to 15.2		Adjust
		DOOWON products(D4A)		19		
Feed pump	Airtightness(When 195 kPa or 2 kgf/cm²) air pressure is applided)			0 cc/min		Adjust
	Priming pump lift capacity (No. of strokes required before lifting when operated at 60 strokes/min			25 strokes or less		Adjust
	Delivery pressure	At 600 rpm	D4AN	175 to 215 Kpa (1,8 to 2.2 kgf/cm²)		Replace
			D4AK-T	335 to 410 Kpa (3.4 to 4.2 kgf/cm²)		
	Delivery amount	For 1 min. at 1,000 rpm through a ø 1.54 nozzle	D4AN	900 cc or more		Replace
		For 1 min. at 1,000 rpm	D4AK-T	1,620 cc or more		

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Unit : mm

Description				Nominal value [Basic diameter]	Limit	Correction and remarks
Feed pump	Lift capacity	When operated at 150 rpm	D4AN	45 sec. or less		Replace
		When operated at 100 rpm	D4AK-T	40 sec. or less		
SCDM auto timer	Flange to shim clearance			0.02 to 0.1		Adjust
	Flyweight to cover clearance			0.05 to 0.2		Adjust
Injection nozzle injection pressure	Orifice diameter 0.3			21.6 to 22.6 MPa (220 to 230 kgf/cm²)		Adjust

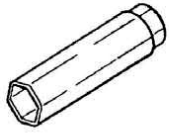
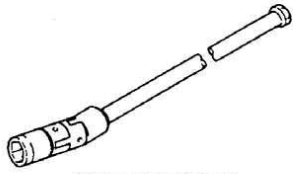
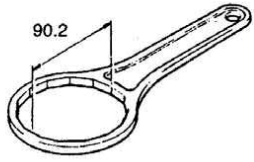
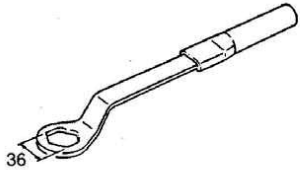
3-1 Tightening Torque Table

Unit : mm

Description			Thread size O.D. × pitch mm	Tightening torque N m(kgf m)
Injection pump	Delivery valve holder	D4A		39 ~ 49 (4 ~ 4.5)
	Screw plug			54 ~ 74 (5.5 ~ 7.5)
	Lock plate	D4AN		7.8 ~ 11 (0.8 ~ 1.1)
		D4AK-T		4.4 ~ 5.9 (0.45~0.6)
RSV governor round nut				49 ~ 59 (5 ~ 6)
Auto timer	Round nut	D4A		83 ~ 98 (8.5 ~ 10)
	Injdection pump gear attaching bolt	D4AK-T		7.8 ~ 12 (0.8 ~ 1.2)
Injection nozzle	Nozzle bridge bolt	D4A	M10 × 1.5	25 (2.5)
	Retaining nut	D4AN		25 ~ 34 (2.5 ~ 3.5)
		D4AK-N	M15 × 0.5	29 ~ 39 (3 ~ 4)
Fuel filter	Fuel feed hose connector bolt		M14 × 1.5	34(3.5)
	Filter element			7.8 ~ 12 (0.8 ~ 1.2)
	Air vent plug		M8 × 1.25	7.8 ~ 12 (0.8 ~ 1.2)
Water separtor connector bolt			M4 × 1.5	34 (3.5)
Secondary fuel filter	Connector bolt		M4 × 1.5	34 (3.5)
	Center bolt		M4 × 1.5	27 ~ 41 (2.8 ~ 4.2)

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4. SPECIAL TOOLS

Tool name	Part number	Shape (Unit : mm)	Use
Socket wrench	31391-14100	 Width across flats 12	● For timing gear case bolt used for removal and installation of injection pump(on-vehicle service) ● Removal and installation of timer round nut
Universal extension	MH061099	 Width across flats 14	Adjustment of fuel injection start timing
Filter wrench	MH061509		Removal of fuel filter element
Cranking handle	MH061289		For engine cranking

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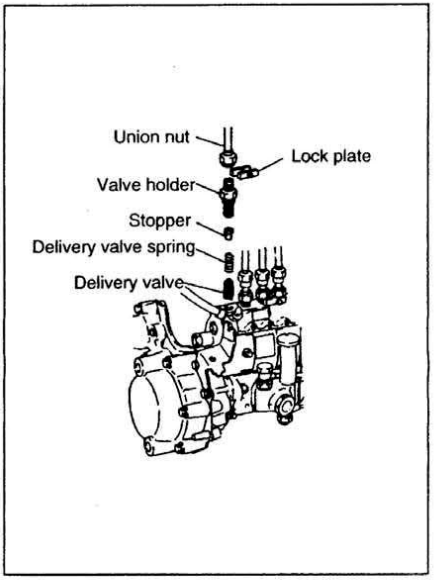
5. SERVICE PROCEDURES

Inspection and Adjustment of Injection Timing

5-1. Inspection

(1) From the injection pump's No.1 cylinder, remove union nut of injection pipe, lock plate, delivery valve holder, stopper, delivery valve spring, and delivery valve.

(2) Fit delivery valve holder 3.

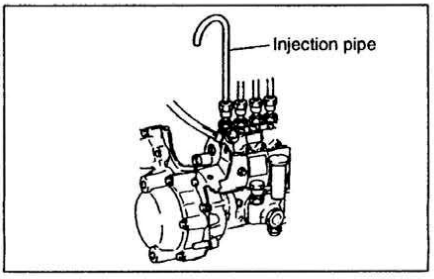


NOTE:

Place all parts in gas oil after removal to keep them free of dust.

(3) Fit an injection pipe onto cylinder No.1 point the pipe's other end downward such that fuel flowing out can be seen cleary.

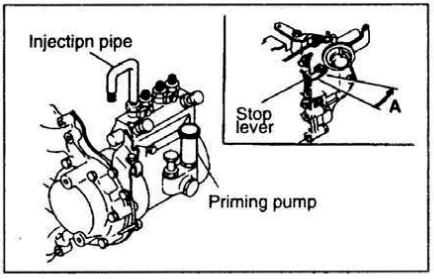
(4) Rotate the crankshaft pulley clockwise(as seen from the front of engine) by at lest 180° and bring cylinder No. 1 to approximately 30° BTDC on its compression stroke.



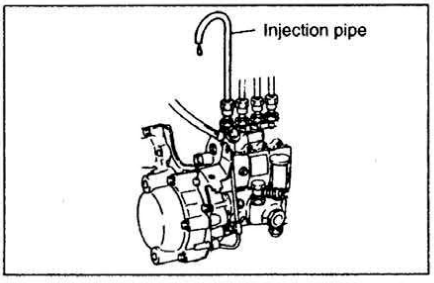
(5) Feed fuel into the injection pump using priming pump. With fuel flowing out of injection pipe, crank the engine slowly clockwise(as seen from the front of engine).

NOTE:

Make sure the stop lever on top of the governor is in its engine starting position A.



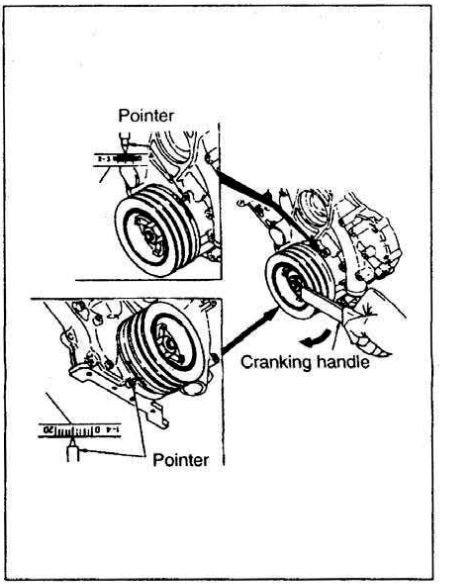
(6) When the flow of fuel from injection pipe diminishes, crank the engine more slowly. When the flow of fuel stops completely, stop cranking the engine.



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(7) Check that pointer on the timing gear case is pointing to inscribed line on the crankshaft pulley which corresponds to the specified fuel injection timing.
If the injection timing should be measured in a dusty location, perform as follows:

- Rotate the crankshaft clockwise(as seen from the front of engine) and bring the No.1 cylinder to 30° BTDC on its compression stroke.
- Disconnect injection pipe with a little amount of fuel remained at the top of delivery valve holder.
- Slowly rotate the crankshaft clockwise. When the injection timing is reached, the fuel at the top of delivery valve holder starts to move.

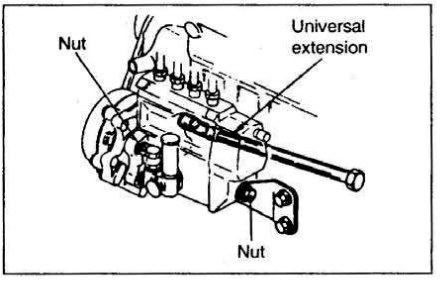


(8) If the fuel injection timing is out of specification, make adjustments in accordance with the following procedure.

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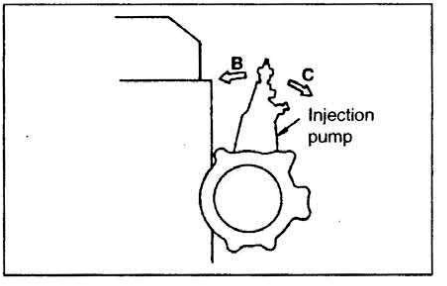
5-2. Adjustment

(1) Lossen injection pump mounting nuts
Nut(4-off; on flange)
Nut(1-off)



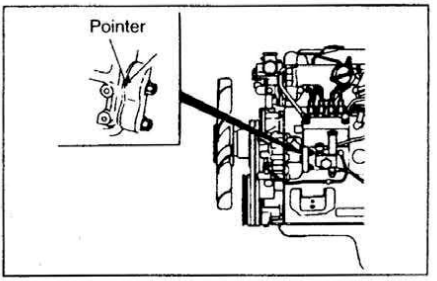
(2) If the fuel injection timing is overly retarded, incline injection pump toward crankcase B.

(3) If the fuel injection timing is overly advanced, incline injection pump away from crankcase C.



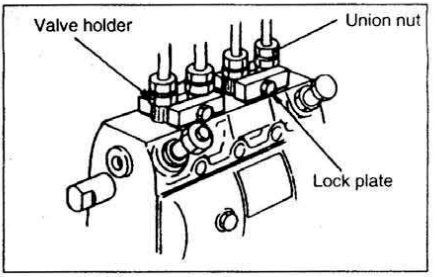
(4) Turning the injection pump by one of gradations inscribed on the timer case flange causes a 6° change in the injection timing.

(5) Tighten nuts then check the fuel injection timing again.



(6) After checking that the fuel injection timing is up to specification, fit delivery valve, delivery valve spring, and stopper, and then delivery valve holder, lock plate and union nut.

(7) Tighten each part to its specified torque.

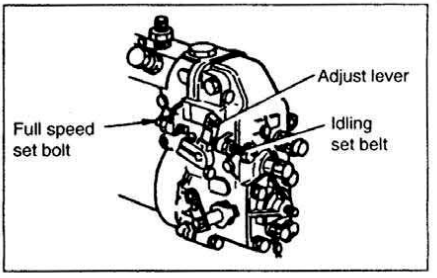


Before making inspections and adjustments, warm up the engine until the coolant reaches 80 to 90℃.

(1) No-load minimum speed

[Inspection]
Confirm that adjust lever is touching idling set bolt. Then check that the minimum speed is up to specification.

[Adjustment]
If the minimum speed is out of specification, adjust it using idling set bolt.



(2) No-load minimum speed

[Inspection]
Confirm that adjusting lever is touching full-speed set bolt. Then, check that the maximum speed is up to specification.

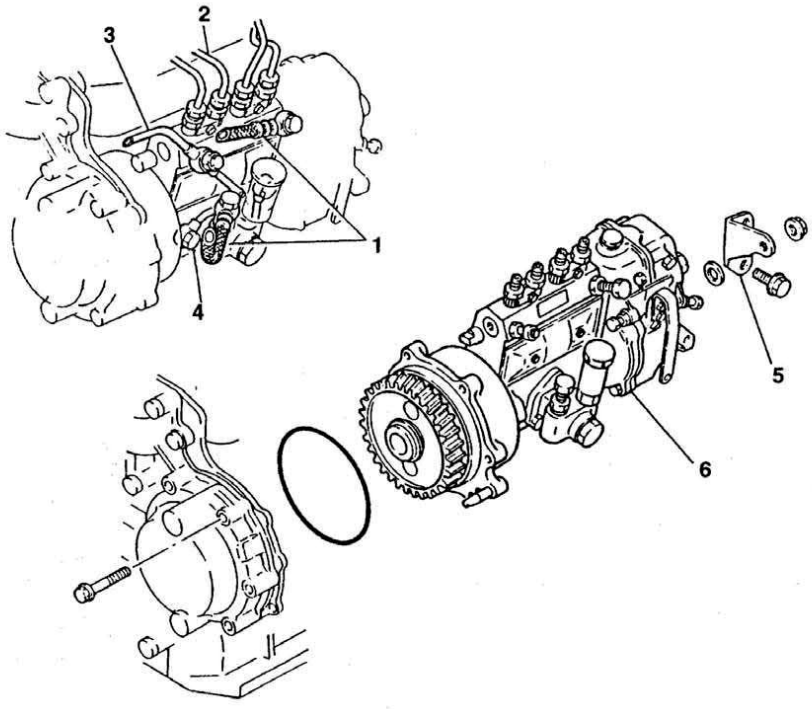
[Adjustment]
If the maximum speed is out of specification, adjust it using full-speed set bolt

NOTE:
Check that the engine does not stall and that no hunting occurs when adjusting lever is moved quickly from the full-speed position to the idling position.
If any abnormality is apparent, make adjustements within the specified range.

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5-3. A Type Injection Pump

5-3-1. Removal

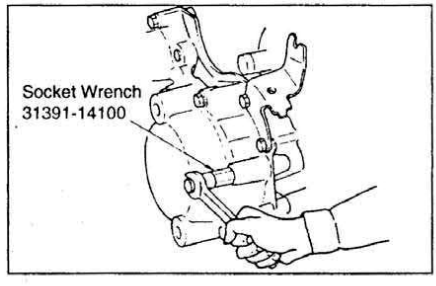


1 Fuel hose
2 Injection pipe
3 Leak off pipe
4 Oil pipe
5 Injection pump stay
6 Injection pump

Hold the injection pump by hand, and remove five timer case attaching bolts.

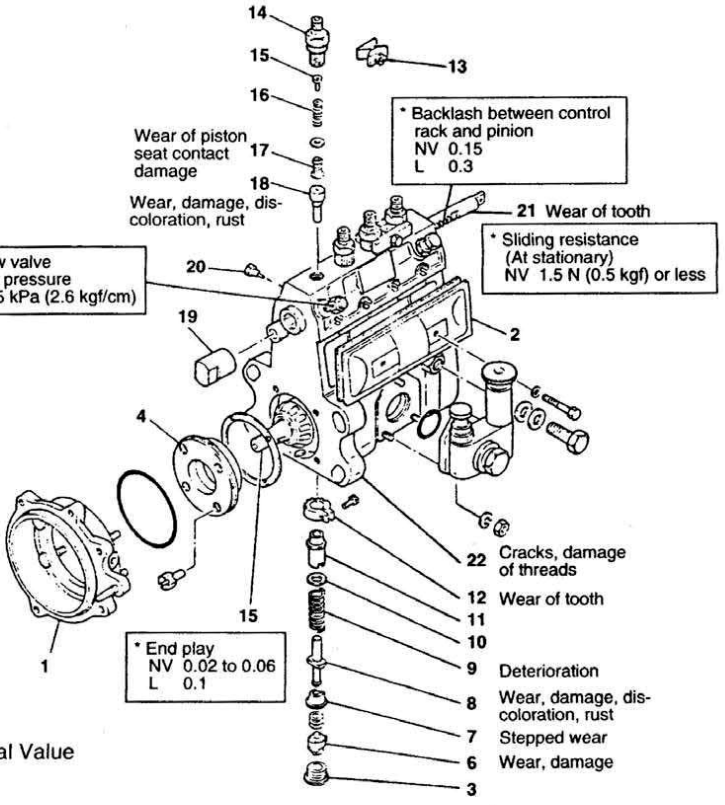
Then, remove the injection pump, pulling it rearward.

Use of Socket Wrench(special tool) will make the removal of timer case attaching bolts easier.



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5-3-2. Disassembly



1	Timer case	9	Plunger spring	⑰	Delivery valve
2	Cover plate	10	Upper spring seat	⑱	Plunger barrel
3	Screw plug	11	Control sleeve	19	Control rack cover
4	Bearing cover	12	Control pinion	20	Rack guide screw
⑤	Camshaft	13	Lock plate	21	Control rack
⑥	Tappet	⑭	Delivery valve holder	22	Pump housing
⑦	Lower spring seat	15	Stopper		
⑧	Plunger	16	Delivery valve spring		

For disassembly of parts with an encircled number, see following items.

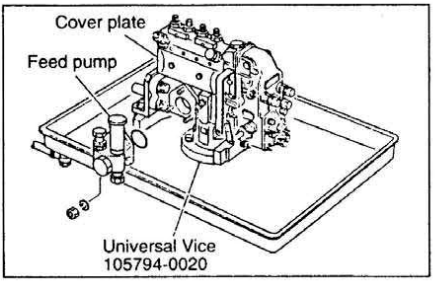
Inspection items marked with * must be checked before disassembly.

NOTE:

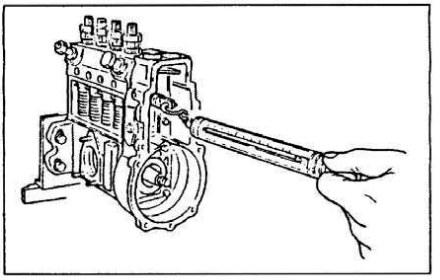
1. **Keep disassembled parts neatly arranged for each cylinder.**
2. **Keep plunger, plunger barrel, and delivery valve in gas oil.**

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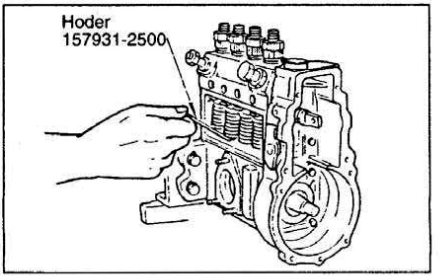
(1) With the auto timer and timer case removed, install the injection pump to the Universal Vise(special tool) and remove following parts.
- Feed pump
- Governor
- Cover plate



(2) Measure the sliding resistance of the control rack.
Turn the camshaft to check that the value is as specified when measured ant any position.
If the measurement exceeds specification, possible cause are:
- Damage on control rack, defective teeth
- Defective pinion teeth, pinion in contact with housing
- Excessively tightened delivery valve holder

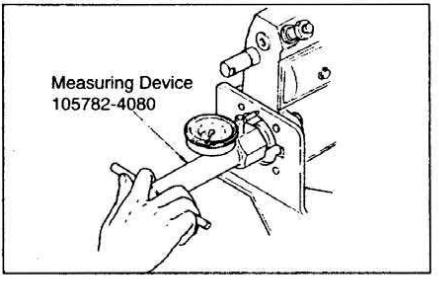


(3) Turn the camshaft to place the tappet at TDC.
Insert Holder(special tool) into the tappet, one by one, to keep them off the camshaft.

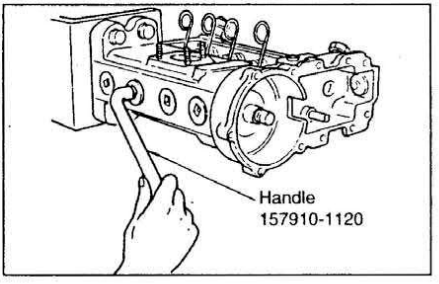


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(4) Install Measuring device(special tool) to the camshaft and measure the end play.

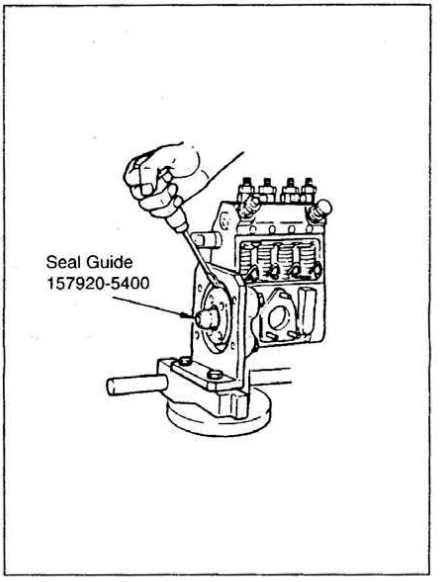


(5) Remove the screw plug from the bottom of injection pump with Handle(special tool).

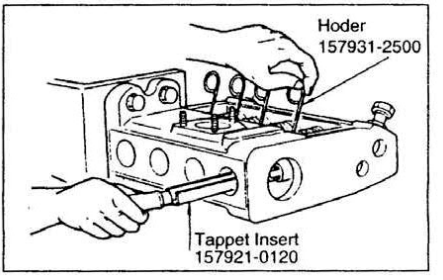


(6) Install Seal Guide(special toll) to the camshaft end(threads and keyway).
Remove the bearing cover by inserting a screwdriver into notches at tap and bottom of bearing cover.
If the bearing cover is hard to remove, tap the camshaft with a soft hammer from the governor end.
Remove camshaft at the same time.

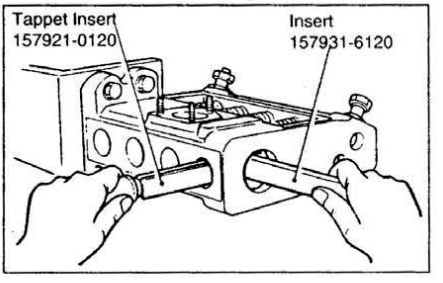
NOTE:
Whenever the bearing cover is disassembled, its oil seals must be replaced with new ones.



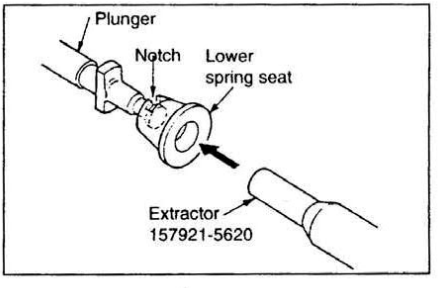
(7) Using Tappet Insert(special tool), push the tappets from under the injection pump. Remove Holders(special tool).



(8) With the tappet held in position with Tappet Insert(special tool) insert Inserter(special tool) into camshaft hole to remove tappet.



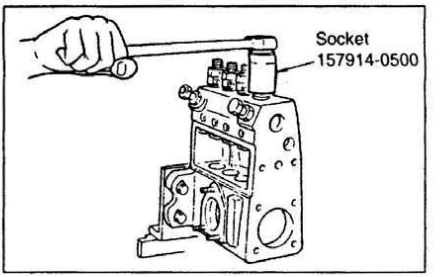
(9) Insert Extractor(special tool) from the bottom of the pump and fix its end to the lower spring seat. Then, withdraw the special tool, which removes the lower spring seat with plunger.
NOTE:
When removing, ensure that the notch in the lower spring seat(for inserting the plunger) faces up to prevent the plunger from dropping.



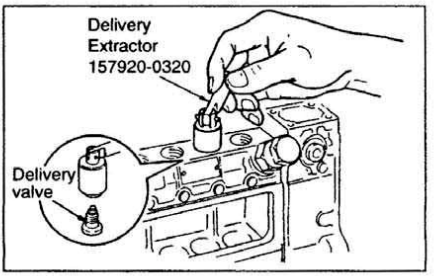
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(10) Measure the backlash between the control rack and pinion. If the limit is exceeded, replace.

(11) Remove the lock plate and use Socket(special tool) to remove the delivery valve holder. Then remove the stopper and delivery valve spring.

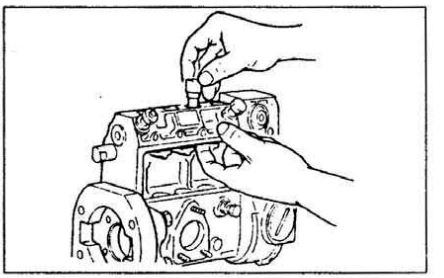


(12) Using Delivery Valve Extractor(special tool), remove the delivery valve.



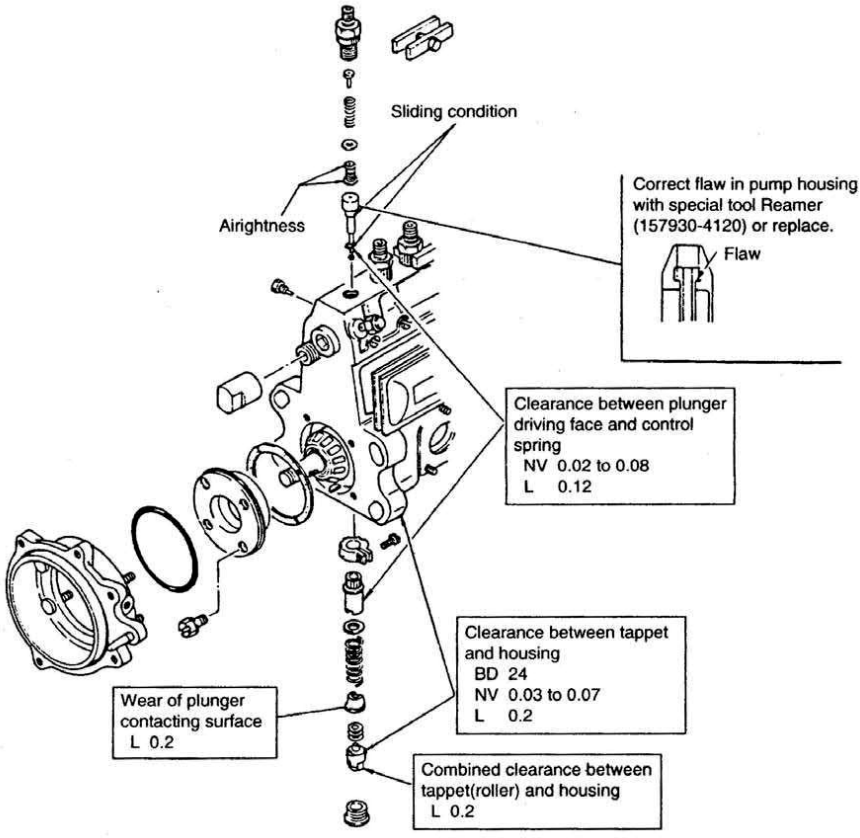
(13) Remove the plunger barrel.

NOTE:
Keep the plunger and plunger barrel in original combination and leave them immersed in gas oil.



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5-3-3. Inspection and Correction



NV ... Nominal Value
L ... Limit

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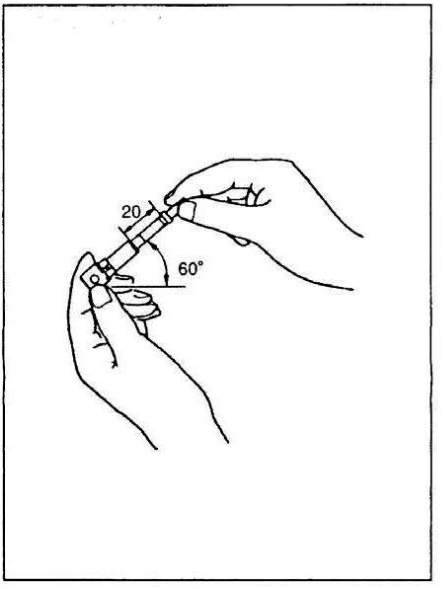
(1) Plunger and Plunger Barrel

After cleaning in gas oil, check to see if the plunger falls smoothly in the plunger barrel by its own weight.

For inspection, use the following procedure:

- Tilt the plunger barrel about 60°.
- Pull the plunger out by about 20mm, and let it go.
- Make the check several times by turning the plunger.

If the plunger does not fall by gravity, replace.



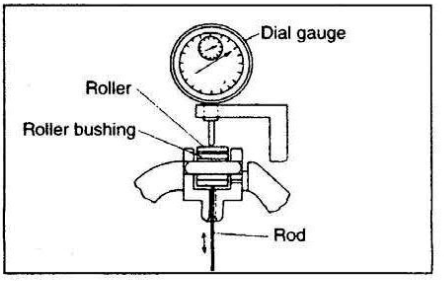
(2) Delivery Valve(with Ungleich Cut)

After cleaning the valve and valve seat of the delivery valve in gas oil, check for wear.

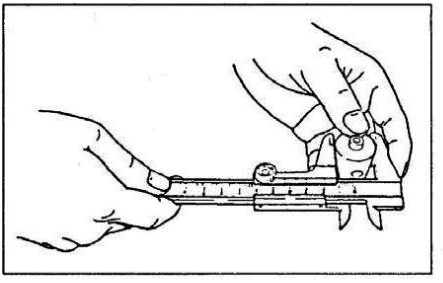
(3) Tappet

Set a dial indicator to the tappet roller and move roller up and down with a rod to check for overall clearance.

If the overall clearance exceeds the limit, replace as a tappet assembly.

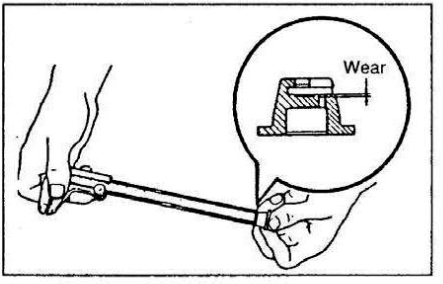


Measure the clearance between the tappet and pump housing and, if the limit is exceeded, replace parts.



(4) Lower Spring Seat

Check the lower spring seat surface in contact with the plunger for wear and, if the limit is exceeded, replace.



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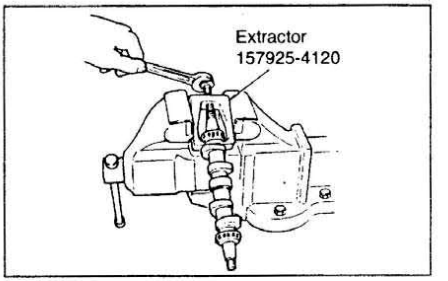
(5) Replacement of Taper Roller Bearing

Inner Race

To remove the inner race, use Extractor(special tool) and remove the roller and inner race from the camshart.

At installation, press-fit the ring, shim, and bearing, in that order.

NOTE:
Install shims of almost the same thickness on both ends of camshaft.

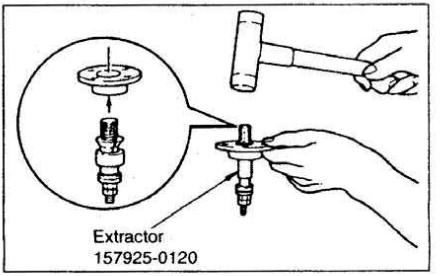


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Outer race

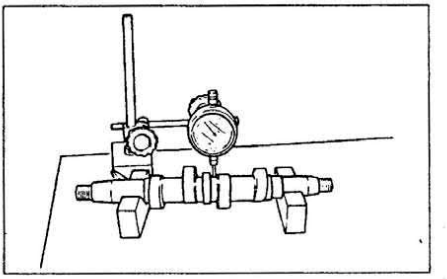
To remove the outer race, use Extractor(special tool).

For installation, use a press.

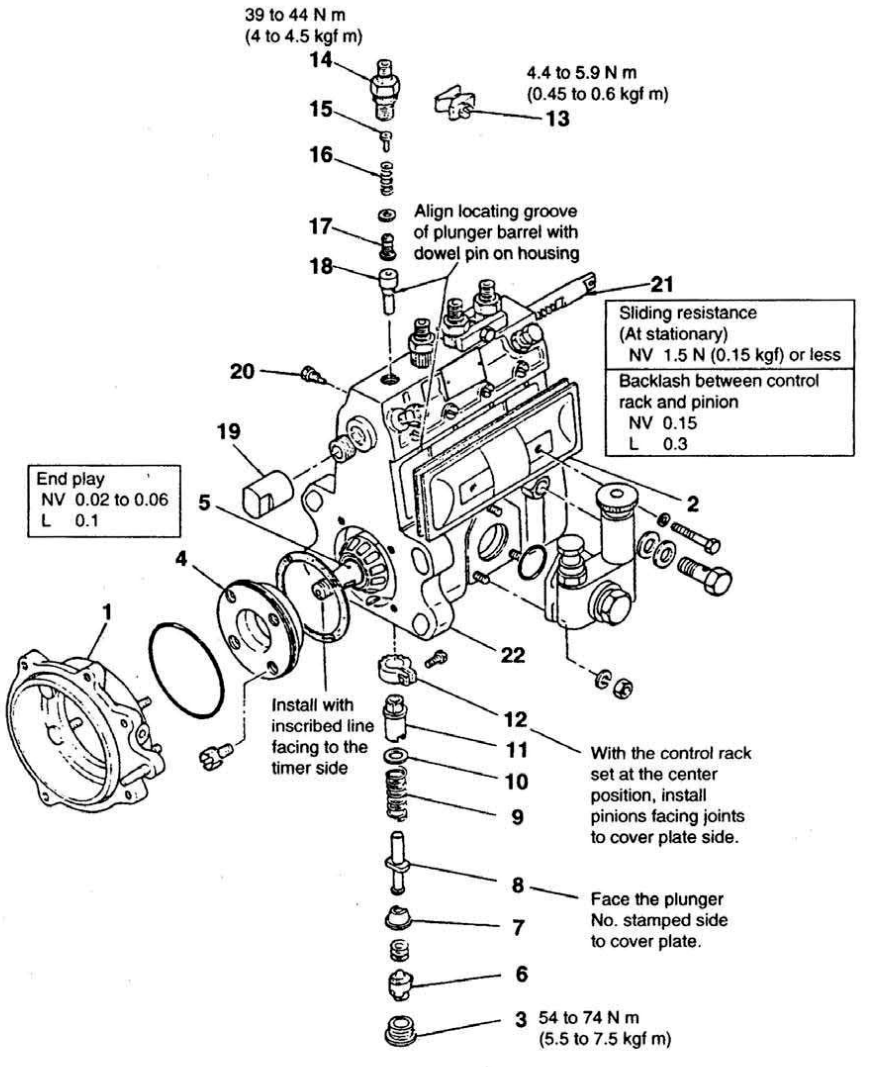


(6) Camshaft Bend(Runout)
Support the camshaft with a V-block at its ends(or the center holes at both ends), and check for bend at the center with a dial indicator.

If the limit is exceeded, correct with a press or replace.



5-3-4. Reassembly



NV ... Nominal Value
L ... Limit

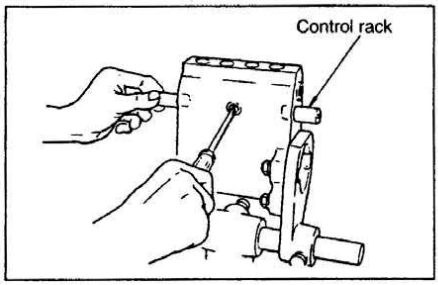
<Assembly sequence>

22→㉑→⑳→⑱→⑰→⑯→⑮→
→⑭→13→10→9→⑥→⑤→
⑪→⑫ ⑧→⑦
→4→3→19→1→1

For reassembly of parts with an encircled number, see following items.

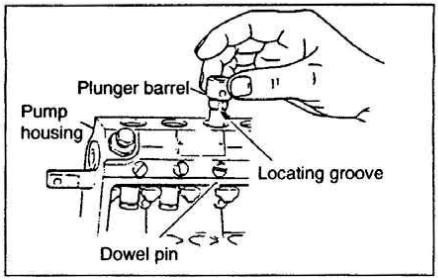
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(1) Mount the control rack and rack guide screw.



NOTE:
Check to see if the rack moves smoothly. Check also if the rack does not turn.

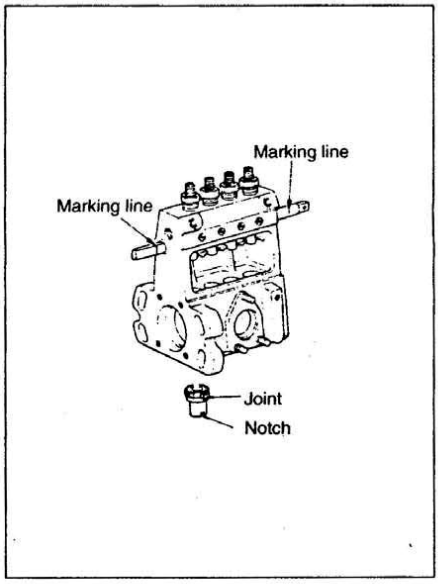
(2) At installation of the plunger barrel into the housing, align the notch in the plunger barrel with the housing knock pin.



NOTE:
Do not tap the plunger barrel, but push into position with a finger.

(3) Place the injection pump horizontally, and set the control rack so that its marking lines are positioned at the same distance away from the housing end faces.

Mate the control pinion with control sleeve and put the pinion in mesh with the control rack teeth.



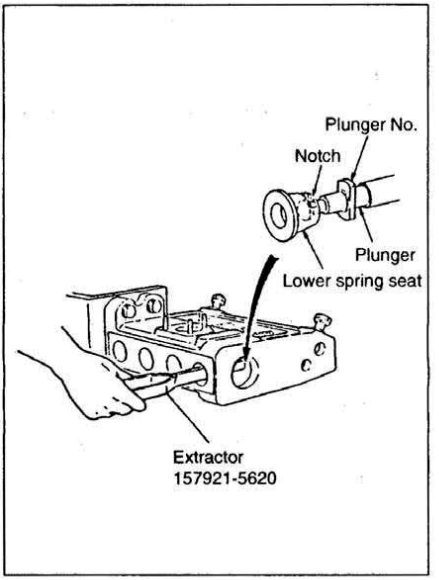
NOTE:

1. **Make sure that the joint of control pinion and notch in control sleeve face toward you.**
2. **Move the control rack each time the pinion is in mesh to ensure that the control pinion joint evens out at right and left. (this is done to ensure an entire rack stroke of 21mm)**

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(4) Fit Extractor(special tool) into the lower spring seat, and install the plunger into the lower spring seat.

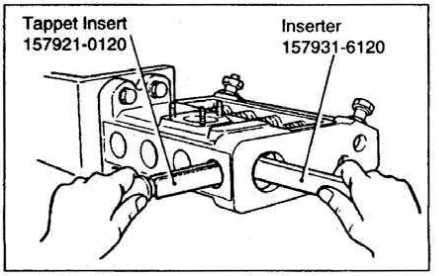
Insert the plunger into the plunger barrel with care not to allow the plunger end to hit the pump housing and plunger spring.



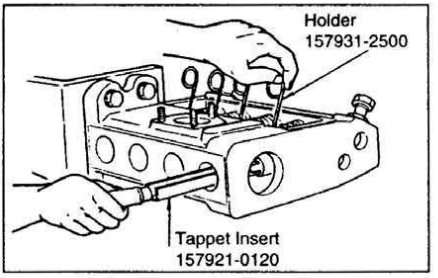
NOTE:

1. **After the plunger has been installed, turn the lower spring seat to face its notch downward.**
   This prevents the lower spring seat from coming off position.
2. **Make sure that plunger flange side with a part number marking faces upward.**

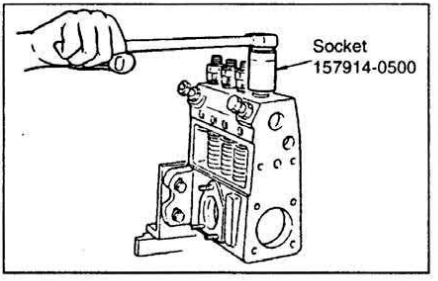
(5) Clamp the tappet with Inserter(special tool) and with the tappet guide aligned with the housing groove, install it into the pump housing.



(6) Using Tappet Insert(special tool), push the tappet to TDC, insert Holder(special tool) and remove Tappet Insert (special tool).
At this time, make sure that the part number marking on the plunger flange is positioned on the cover plate side.
For each cylinder, check the control rack for sliding condition each time Holder(special tool) is installed.

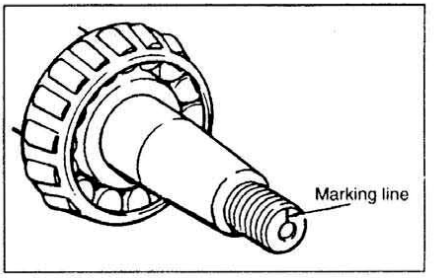


(7) Using Socket(special tool), install the delivery valve holder.

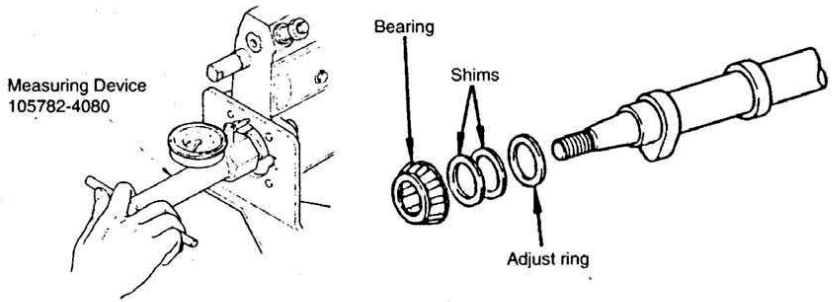


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(8) Install the camshaft with the marking line at the end of its thread facing toward the drive end.



(9) Temporarily mount the bearing cover to measure the camshaft end play with Measuring Device(special tool). If the limit is exceeded, adjust with shims or replace bearing.



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NOTE:
Use shims of almost equal thickness for the governor and timer end.

Shim Thickness

Timer end	0.10, 0.12, 0.14, 0.16, 0.18, 0.30, 0.50, 1.00 mm
Governor end	0.10, 0.12, 0.14, 0.16, 0.18, 0.30, 0.50, 0.70, 1.00, 1.40 mm

After installing the bearing cover in position, measure again end play to ensure that it is up to specification.

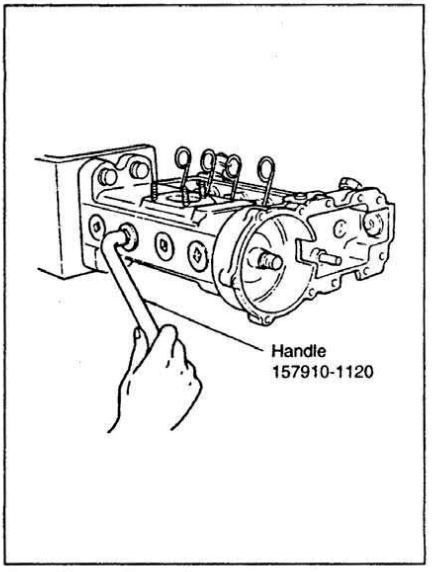
(10) With Tappet Insert(special tool) removed, measure the sliding resistance of the control rack.

(11) Apply sealant to screw plug and install it with Handle(special tool).

(12) Install the governor.

(13) Install the following parts after adjusting the injection pump:

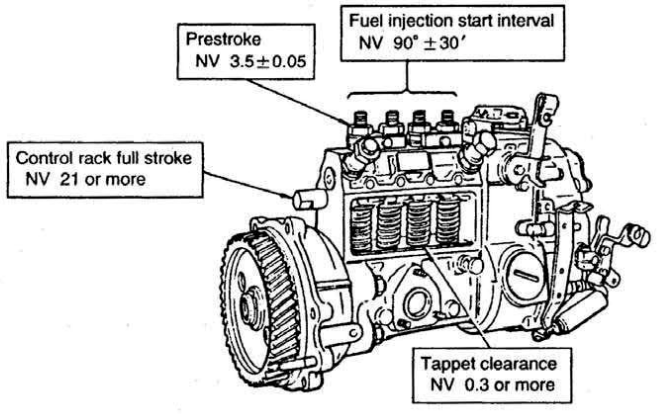
- Control rack cover
- Cover plate
- Timer case
- Feed pump
- Auto timer



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5-3-5. Adjustment after Reassembly

For fuel injection rate adjusting standard, see Service Information separately published.

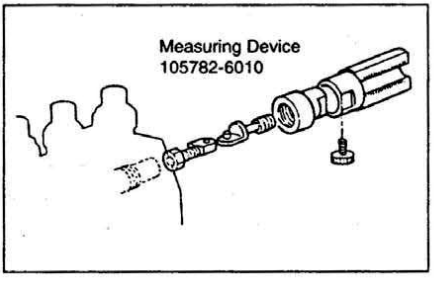


NV ... Nominal Value

NOTE:
Feed oil to the injection pump cam chamber.

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(1) Control Rack "O" position setting



Install Measuring Device(special tool) on the injection pump.

Temporarily set the adjusting lever to maintain the injection pump speed at 500 to 600 rpm. Further increase the speed to pull the control rack; at the same time, push the control rack fully.

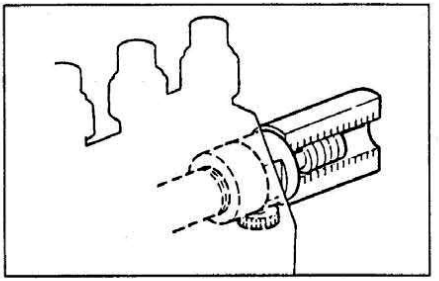
With this position of control rack regarded as "O", set "O" on the Measuring Device scale to the position.

NOTE:
If zero position is set by the adjusting lever operation without running the injection pump, the governor linkage could be damaged. Do not use the adjusting lever to set the zero position.

(2) Control Rack Stroke Check

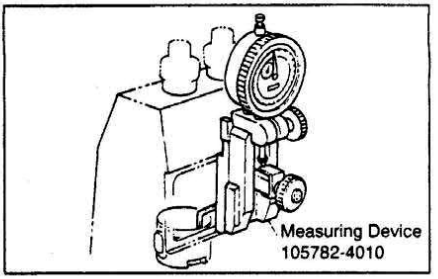
Move the control rack to check its stroke is more than the specified value.

Ensure also that the start spring and idling spring move the control rack smoothly in the direction to increase the amount of fuel injected.



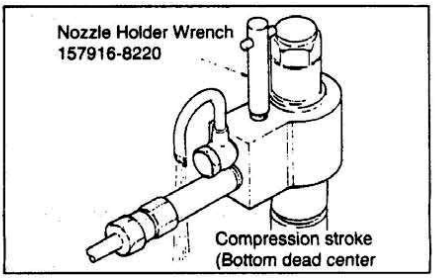
(3) Prestroke Check

(a) With the control rack withdrawn and fixed in the full injection position, install Measuring Device(special tool).



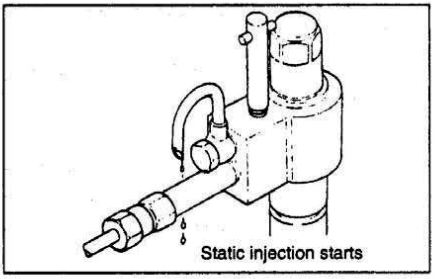
(b) With No.1 cylinder plunger at BDC, send fuel to injection pump under high pressure pump of the pump tester and install Nozzle Holder Wrench(special tool) to test nozzle to let the fuel flow out from overflow pipe.

NOTE:
The fuel pressure must be over the delivery valve opening pressure.



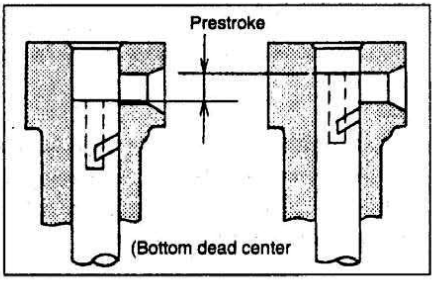
(c) Slowly turn the tester coupling until the fuel stops flowing out of the test nozzle overflow pipe(static injection starts).

NOTE:
Measurement must be made with the camshaft turned in the normal rotating direction(clockwise as viewed from the drive end).



(d) Read the prestroke of plunger on the indicator, from BDC until fuel stops flowing.

If the prestroke is out of the nominal value, adjust as follows.



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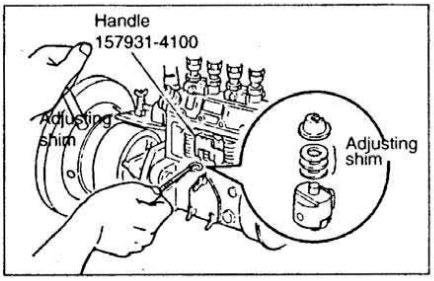
(4) Adjustment of Prestroke

With the tappet at TDC, insert Holder(special tool) between the lower spring seat and tappet.

Turn camshaft, and you have a clearance between the lower spring seat and tappet. Increase or decrease shim thickness to fill the clearance, to adjust the prestroke.

A greater shim thickness makes prestroke smaller.

A smaller shim thickness makes prestroke greater.

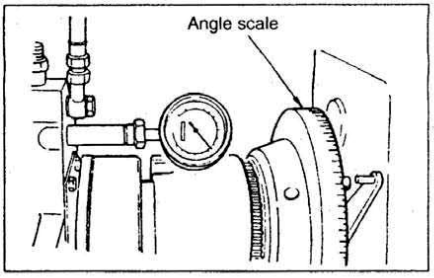


(5) measurement of Injection Start Interval

With the static injection start of NO.1 cylinder used as a basis, read the injection start interval of each cylinder according to the injection sequence using an angle scale of the tester. If the interval is out of specification, adjust as in prestorke adjustment.

Injection Sequence

1→3→4→2

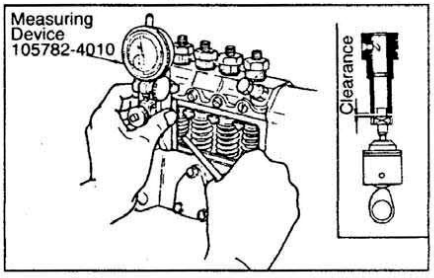


(6) Tappet Clearance measurement

Install Measuring Device(special tool) and turn the camshaft to bring the tappet to TDC.

Push up the tappet and measure the lift for the plunger flange top to come into contact with the plunger barrel.

If the tappet clearance is out of specification, adjust within the allowable range of injection start interval. If the range does not permit correction, read just with No1. 1 cylinder prestroke at the maximum nominal value.



(7) Fuel Injection Rate Adjustment

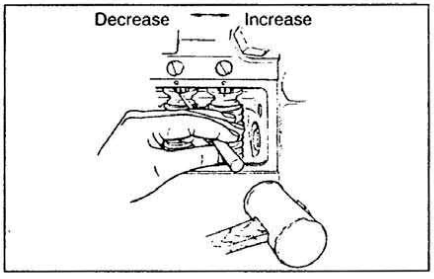
Measure the fuel injection rate and uneven ratio at the specified rack position and speed.

If the injection rate is out of specification, adjust as follows.

(a) Loosen pinion clamp screw.

(b) With the control rack held in position, turn the control sleeve with the adjusting rod.

(c) Tighten pinion clamp screw.



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NOTE:

1. **Use special care to make the adjustment. Improper or failure of adjustment greatly influences engine performance engine.**
2. **The fuel injection rate vaies with nozzle and pipe used. Observe measuring requirements strictly.**
3. **Uneven ratio**

$$\text{Uneven ratio(+)} = \frac{\text{Max. fuel injection rate in each cylinder} - \text{Average fuel injection rate in each cylinder}}{\text{Average fuel injection rate in each cylinder}} \times 100$$

$$\text{Uneven ratio(-)} = \frac{\text{Min. fuel injection rate in each cylinder} - \text{Average fuel injection rate in each cylinder}}{\text{Average fuel injection rate in each cylinder}} \times 100$$

(8) Adaptation to Engine

After the governor has been adjusted, measure the fuel injection rate adaptable to the engine.

(9) Inspection of Fuel and Oil Leaks

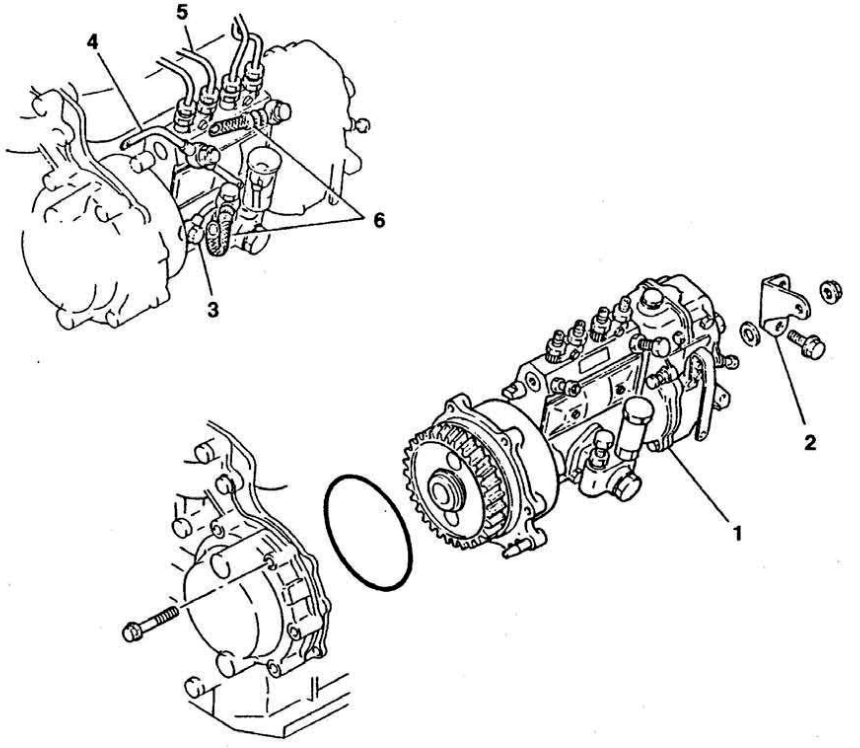
Fuel leaks from delivery valve attaching portion and other parts oil leaks from oil seals and other parts.

(10) Inspection of Parts

Check parts for unusual noise and bearings for excessive heat.

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5-3-6. Installation



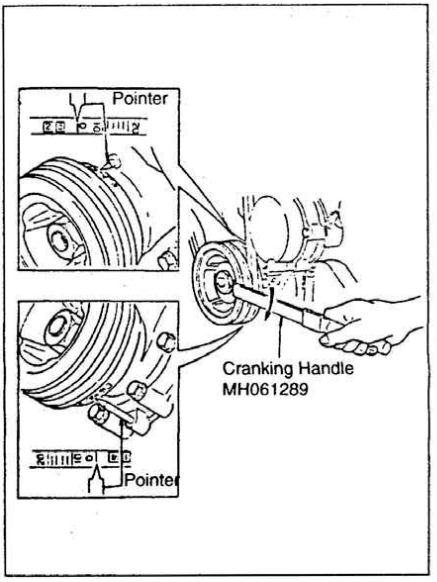
1 Injection pump
2 Injection pump stay
3 Oil pipe
4 Leak off pipe
5 Injection pipe
6 Fuel hose

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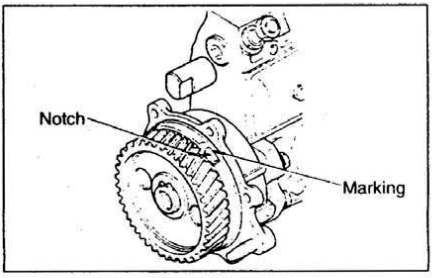
(1) Set the piston of the engine No.1 cylinder at the top dead center on compression stroke. For this purpose, use Cranking Handle(special tool) to crank the engine until the engraved line "0" position on the side bearing "1.4" mark of the crankshaft pulley is lined up with the pointer.

In the case of D4A, another pointer is on top of the crankshaft pulley and if this pointer is used, align the engraved line "0" position on the side bearing "2.3" mark of the crankshaft pulley with the pointer.

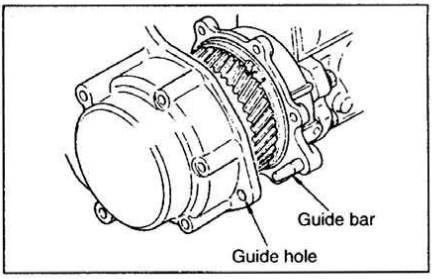
At this time, if the intake and exhaust valves of the No.1 cylinder are not pushed up by the push rod, the No.1 cylinder is at the top dead center on compression stroke. If the intake and exhaust valves are pushed up by the push rod, turn the crankshaft through 360 degrees.



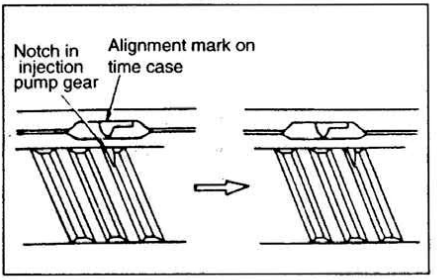
(2) Line up the marking on the timer case with the notch in the injection pump gear.



(3) Insert the guide bar on the timer case into the guide hole in front plate. Using this as a guide, push until the injection pump gear is about to be in mesh with the idler gear.



(4) Make sure that the alignment mark of the injection pump gear is aligned with that of the timer case. Then, push in the injection pump. At the time, the alignment mark on the gear moves to the end of that on the timer case.



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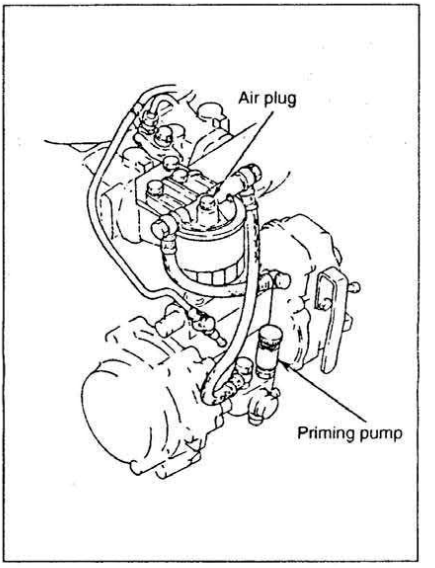
5-3-7. Bleeding the Fuel System

Here is the procedure for bleeding the fuel system.

(1) Turn the injection pump priming pump counterclockwise until it comes loose.
(2) Loosen the air plug of the fuel filter.
(3) Move the priming pump up and down by hand to feed fuel until air bubble does not come out from the air plug.
(4) When no air bubble comes out in fuel, keep the priming pump down and turn it clockwise until it fits into position, Then, tighten the air plug.

NOTE:

1. **The air plug must be tightened after the priming pump is secured into position.**
2. **Sop up fuel spilt around.**

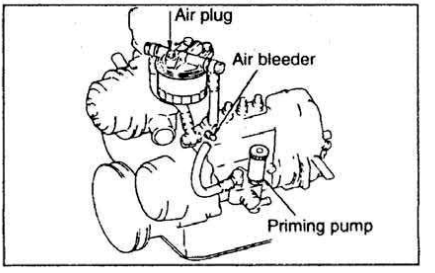


(5) Actuate the starter to discharge air from the injection pump.

NOTE:

Do not operate the starter for more than 15 seconds.

The injection pump is provided with an air bleeder which can be loosened for bleeding as with the fuel filter.



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5-3-8. Inspection and Adjustment after Installation (Fuel Injection Timing)

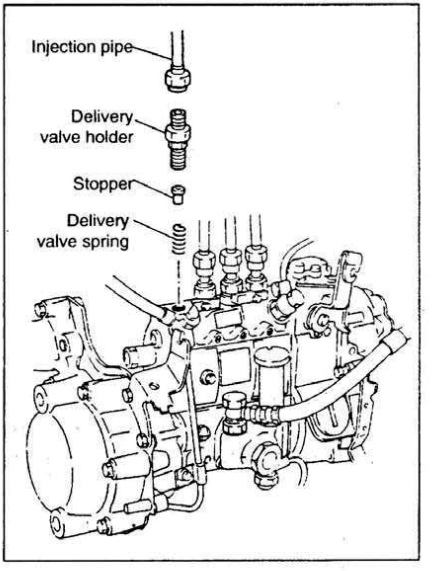
(1) Remove the injection pipe, delivery valve, delivery valve spring, and stopper fromNo.1 cylinder of the injection pump. Keep the delivery valve holder attached.

NOTE:

Keep disassembled parts in gas oil to prevent contamination by dust and dirt.

(2) Install a spare injection pipe to No.1 cylinder. Face the other end of the pipe downward for easier observation of fuel flow out condition.

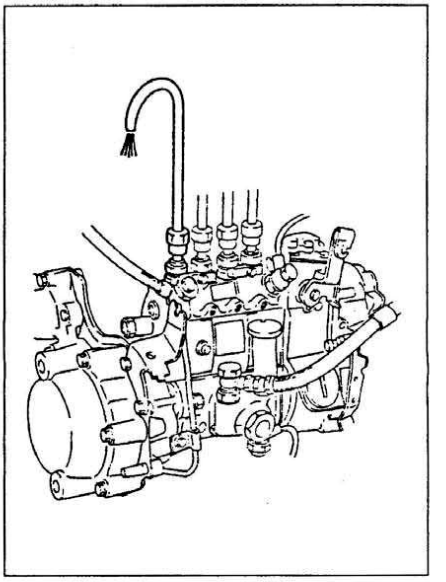
(3) Crank the engine to bring the piston in No.1 cylinder 30° before top dead center.



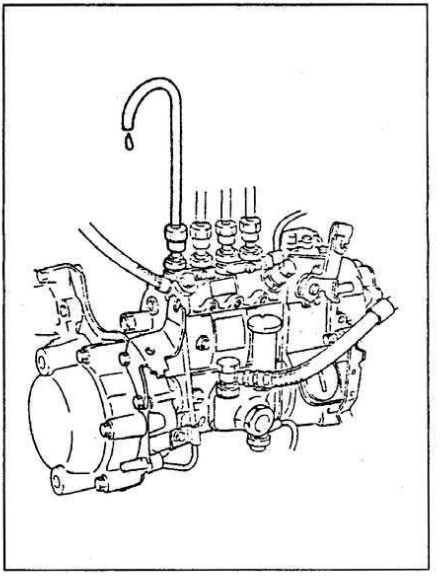
(4) While operating the priming pump to let fuel run out from the injection pipe, slowly crank the engine in the direction of normal rotation.

NOTE:

Make sure that the stop lever on the governor is not pulled toward the STOP position.



(5) Crank the engine even more slowly as the fuel is about to stop flowing out from the injection pipe. Stop cranking as soon as no more fuel comes out from the pipe.



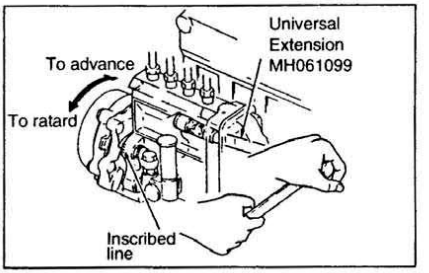
(6) Check that the inscribed line on the flywheel and the pointer indicate the position about 2 degrees before the fuel injection timing.

NOTE:

1. **The injection timing is advanced by about 2 degrees from specified timing as the delivery spring's valve opening pressure does not work.**
2. **The injection timing is indicated at the caution plate on the rocker cover.**

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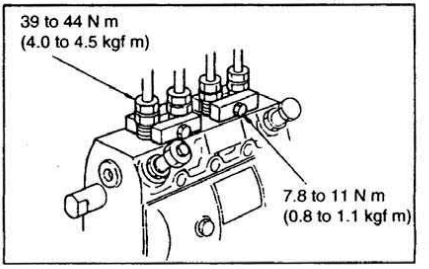
(7) Loosen the injection pump attaching nut with Universal Extension(special tool).



(8) To advance the fuel injection timing, move the injection pump toward the crankcase side.
To retard the timing, move the injection pump away from the crankcase.

(9) Move the injection pump to the desired direction. A shift of one graduation of the adjustment marker varies the injection timing by 3 degrees.

(10) With the injection pump attaching nut tightened, measure the injection start timing again.



(11) After the adjustment has been made, install the delivery valve, delivery valve spring, and stopper and tighten the delivery valve holder to specification. Then, install the injection pipe.

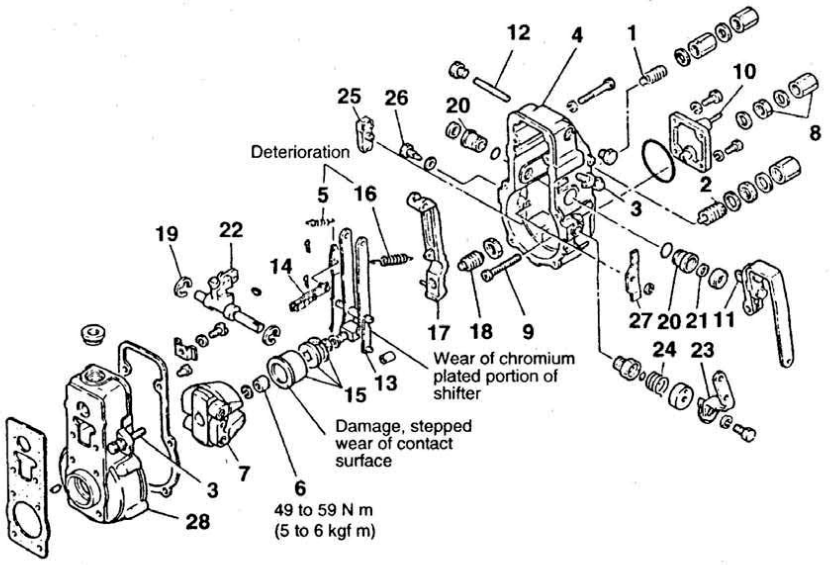
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(12) For inspection at dusty locations, proceed as follows.
(a) Remove only the injection pipe and keep a small amount of fuel remaining at the top of delivery valve holder.
(b) Crank the engine to bring the piston in No. 1 cylinder to a position about BTDC 30° on the compression stroke. Further crank the engine slowly, and the fuel on top of the delivery valve will begin to move.
(c) This is the fuel injection start timing.

NOTE:
If the fuel ijection timing is radically different from the specification and the deviation is beyond the adjustable range of the injection pump, the engine timing gear and injection pump gear are not probably in proper mesh. In this case, remove the injection pump and reinstall it.

5-4. RSV Type Governor

5-4-1. Disassembly, Inspection and Reassembly



<Diassembly sequence>

1	Idling subspring adapter	⑮	Governor sleeve
2	Torque spring adapter	⑯	Governor spring
3	Stopper	17	Tension lever
④	Governor cover assembly (8 to 27)	18	Ungleich spring adapter
5	Start spring	19	Snap ring
⑥	Round nut	20	Lever bushing
⑦	Flyweight	21	Oil seal
8	Cap nut, Lock nut	㉒	Swivel lever
9	Full load stopper	23	Stop lever
10	Cover	24	Return spring
11	Adjusting lever	25	Supporting lever
12	Supporting lever shaft	26	Support pin
⑬	Guide lever assembly	27	Torque control lever
14	Shackle	28	Governor housing

For disassembly and reassembly of parts with an encirled number, see following items.

NOTE:

1. **Do not disassemble the shackle and governor sleeve from the guide lever, unless replacement is necessary.**
2. **Do not remove the governor housing unless removal is necessitated for correction of oil leaks, parts replacement, etc.**
   Before removing the housing, use Tappet Insert(special tool) to separte the camshaft from the tappet.

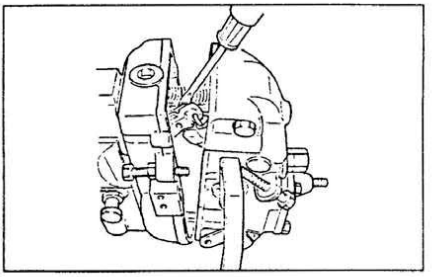
For reassembly, reverse the order of disassembly.

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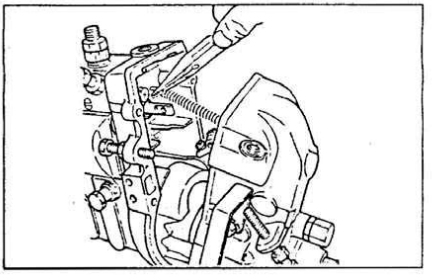
1. Disassembly Procedure

(1) Remove the governor cover assembly from the governor housing.

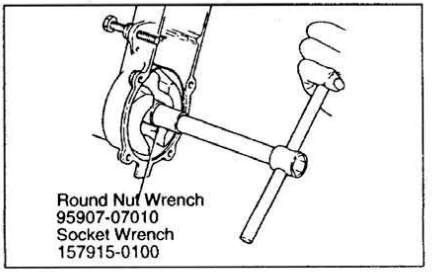
Open the governor cover slightly to the front and slide downward the shackle latch connected to the control rack to disconnect it from the control rack.



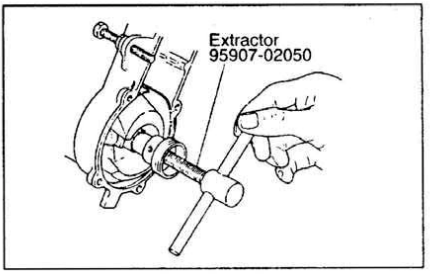
(2) Remove the start spring using long-nose pliers.



(3) Remove the round nut using Socket Wrench or Round Nut Wrench (special tools).



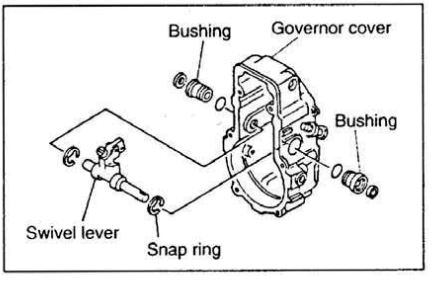
(4) Screw in Extractor(special tool) to the flyweight and extract it.



(5) Removal of Swivel Lever

Remove the snap ring from the lever bushing and tap lightly the swivel lever shaft from the adjusting lever mounting side to remove the bushing from both ends. Then, remove the swivel lever.

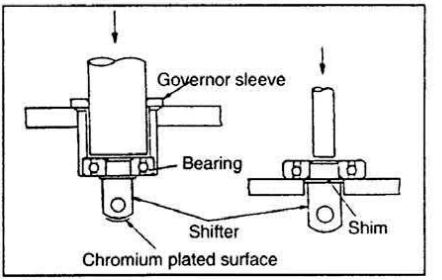
NOTE: Do not remove the swivel lever from the governor cover unless such removal is necessary for parts replacement or for correcting unsmooth motion.



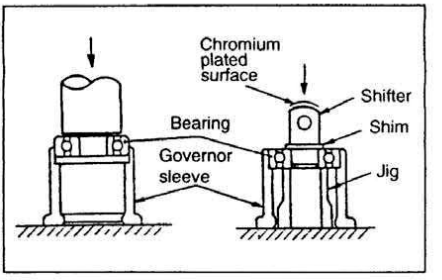
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(6) Replacement of the Governor Sleeve or Guide Lever

(a) Using a press, remove the bearing in the governor sleeve and remove the guide lever assembly shifter from the bearing.



(b) Press-fit the bearing to the governor sleeve.
Press-fit the guide lever assembly shifter to the bearing.



(c) Make sure that the sleeve turns smoothly.
NOTE:

1. **Do not replace the shim as its thickness has been established.**
2. **During removal and installation take care not to damage the chromium plated surface of the shifter.**

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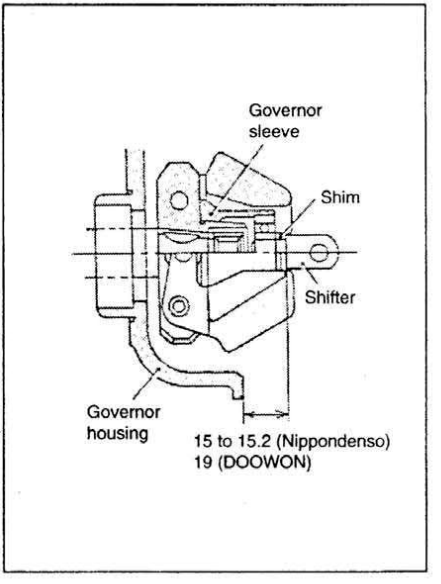
2. Reassembly procedure

(1) If shims have to be replaced, assembly the associated parts correctly and select the thickness of shims that gives correct housing end to shifter dimension.

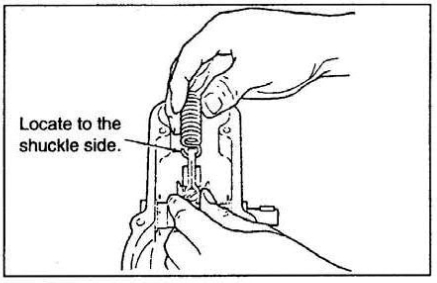
Shim Thickness

(5 types)
0.1, 0.2, 0.3, 0.4, 1.0 mm
(6 types)
0.2, 0.3, 0.4, 0.5, 1.0, 1.5 mm

NOTE:
Measure the assembled dimension without lifting the flyweight.



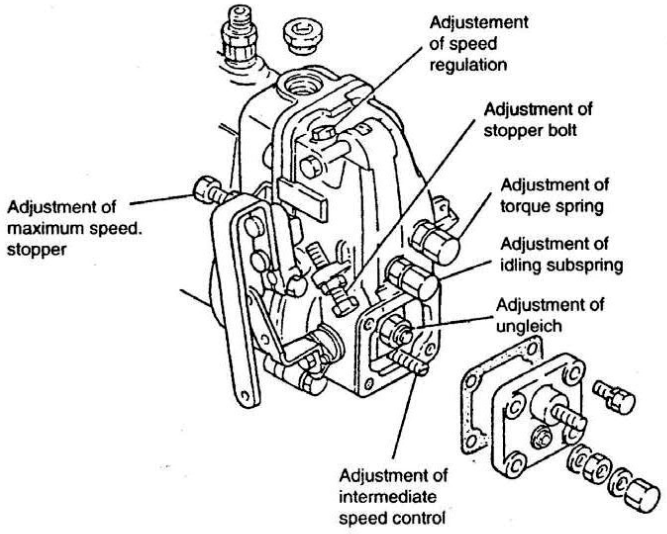
(2) When mounting the governor spring to the swivel lever, position the spring so that its end faces the shackle.



5-4-2. Adjustment after Reassembly

For governor performance curve, see Service Information separately published.

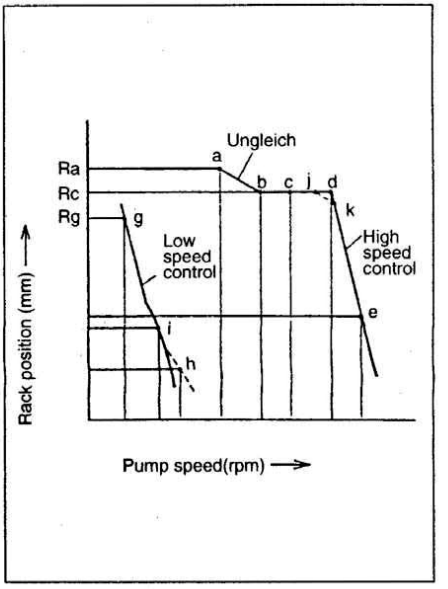
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NOTE:

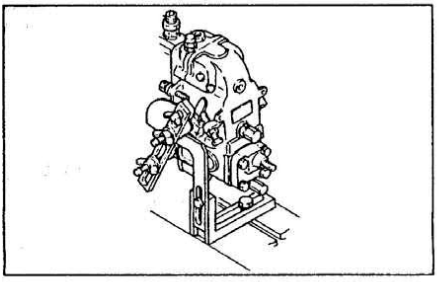
1. **Supply engine oil to the injection pump cam chamber.**
2. **Loosen the adjusting lever stopper bolt.**
3. **Remove the idling subspring.**
4. **Do not allow the Ungleich spring and torque spring to work.**

Adjust the relationship between the pump speed and the rack position to the specified governor performance curve as follows.



(1) "0" Position Setting of Control Rack

(2) Mount the angle scale plate for the adjusting lever fixing device.



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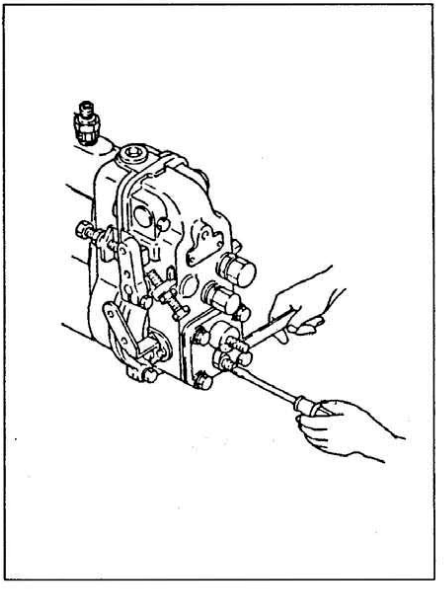
(3) Adjustment of Intermediate Speed Control

This adjustment sets the control rack position point C(maximum injection) when the injection pump is at full load.

With the injection pump at Nc rpm, set the adjusting lever to its tilted position where the governor spring in the governor is tensioned fairly strongly and hold the lever at that position temporarily.

Then, adjust the full load stopper to bring the control rack to the Rc position.

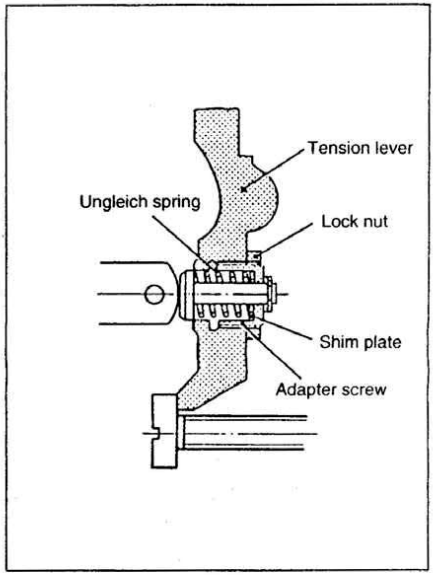
Turning the full load stopper clockwise as viewed from the rear of the governor moves the rack in the direction that fuel is increased and turning in counterclockwise moves the rack in the direction that fuel is decreased.



(4) Adjustment of Ungleich

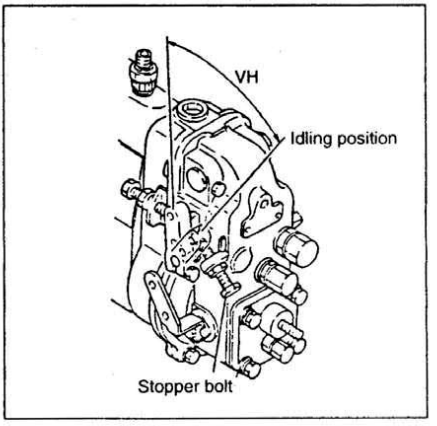
Set the adjusting lever at the maximum speed stopper position.
Adjust the adapter screw so that the rack position changes from Ra to Rc when the speed is changed from Na to Nb. The change in the rack position from Ra to Rc is called the Ungleich stroke.
Tightening the adapter screw increases the Ungleich stroke and loosening the screw decreases the Ungleich stroke.
Change the thickness of shim plate(Nippondenso products) the Ungleich spring assembly(DOOWON products) so that the rack is positioned at Ra when the speed is Na.

Shim Thickness(4 types)
0.10, 0.20, 0.25, 0.50 mm

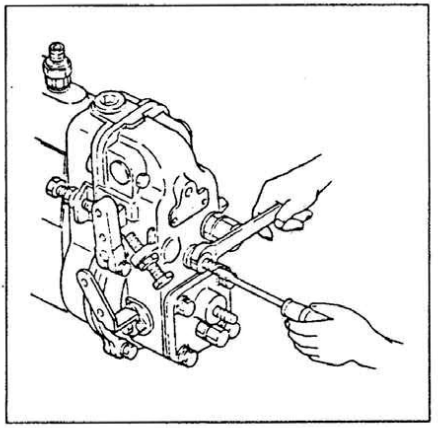


(5) Adjustment of Low Speed Control

(a) Adjustment of stopper bolt
While rotating the pump at Ni, tilt the adjusting lever and adjust the stopper bolt to bring the control rack to the Ri position.



(b) Adjustment of idling subspring
Adjust the idling subspring so that the rack is positioned at Rh when the pump is running at a speed of Nh.
Then, decrease the pump speed and check that the rack is positioned at Rg ant the pump speed of Ng.



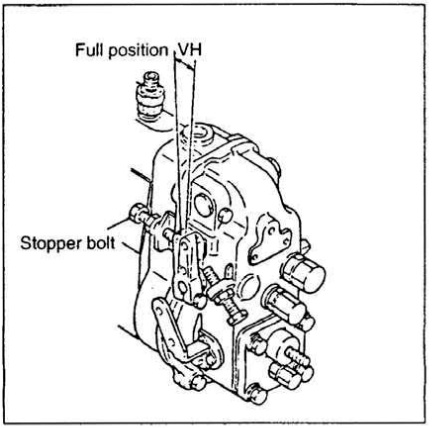
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(6) Adjustment fo High Speed Control

(a) Adjustment of maximum speed stopper

Tilt the adjusting lever and set the maximum control speed of the governor.

Tilt the adjusting lever and adjust the maximum speed stopper so that the control rack is moved from the Rc position when the pump speed increased slowly from Nc reaches Nd.



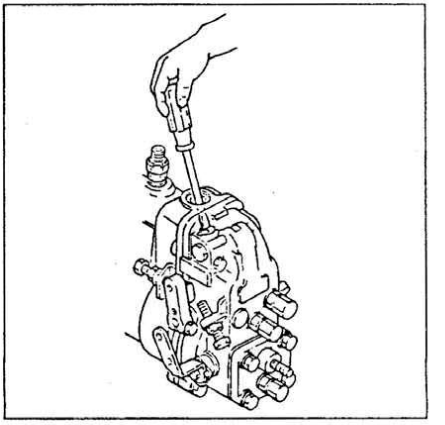
(b) Adjustment of speed variation rate

Increase the pump speed from Nd and check to see that when the speed reaches Ne, the rack position is pulled back to Re.

If it is out of specification, adjust the amount the adjusting screw of the swivel lever is turned down.

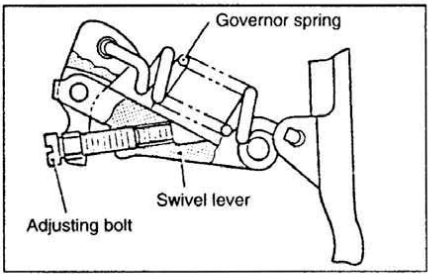
Tightening the screw will improve the speed variation rate.

Loosening it will worsen the speed variation rate.



Speed variation rate

$$= \frac{Ne - Nd}{Nd} \times 100(\%)$$



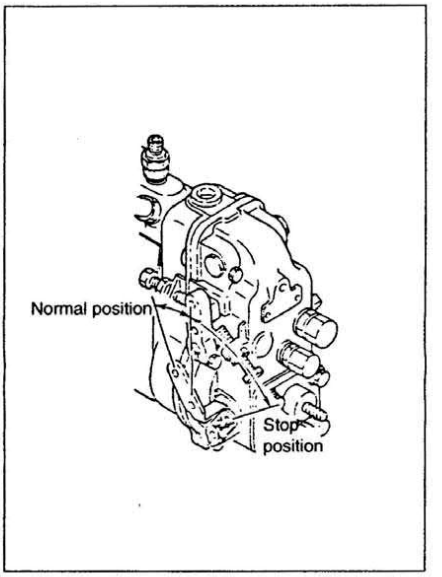
NOTE:

1. **If the variation rate is poor, the engine will exceed the specified maximum speed at no load and will enter a hazardous condition.**
2. **The maximum extent to which the adjusting screw can be loosened is 20 notches(5 rotations) from the fully tightened position. Loosening it any further can be dangerous.**
3. **If the adjusting screw is adjusted, the tension of the governor spring will change and the high speed control start point will change. Make sure that the maximum speed stopper under Item(a) is readjusted.**

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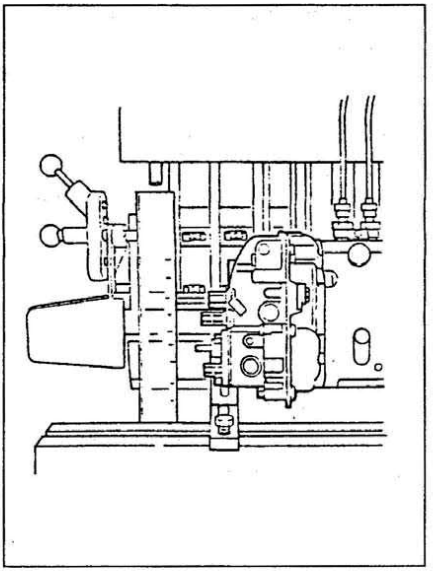
(7) Stop Lever Operation Check

With the injection pump at full load, move the stop lever fully to the stop side and check that this moves the rack to the 0mm position.



(8) Adjustment for Adaptation to engine

Upon completion of the governor adjustment, measure the total injection amount with the lever set at the same angle as in the high speed control in accordance with the adjustment standard and adjust as necessary.



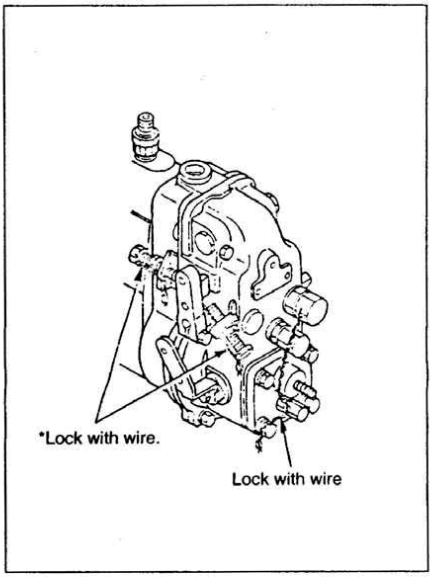
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(9) Sealing

After all adjustments have been made, seal the governor as follows.

NOTE:

Sealing of the sections marked with * must be done after adjustment of no-load minimum and maximum speeds.



5-4-3. Inspection and Adjustment of No-load Minimum and Maximum Speeds

Start engine and warm up sufficiently. After the temperature of coolant exceeds 60℃,
perform the following inspection and checks.

(1) Minimum Speed

(a) Make sure that the adjusting lever is in contact with the idling set bolt.

(b) In this state, measure the minimum speed to ensure that it is within the specification.

(c) If the measurement is out of the specification, use the set bolt for adjustment.

(2) Maximum Speed

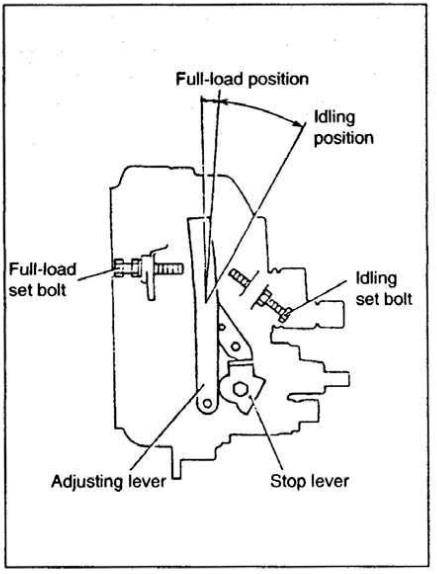
(a) Operate the adjusting lever to the position where it touches the full load set bolt.

(b) In this state, measure the maximum speed to ensure that it is within the specification.

(c) If the measurement is out of the specification, adjustwith full load set bolt.

NOTE:

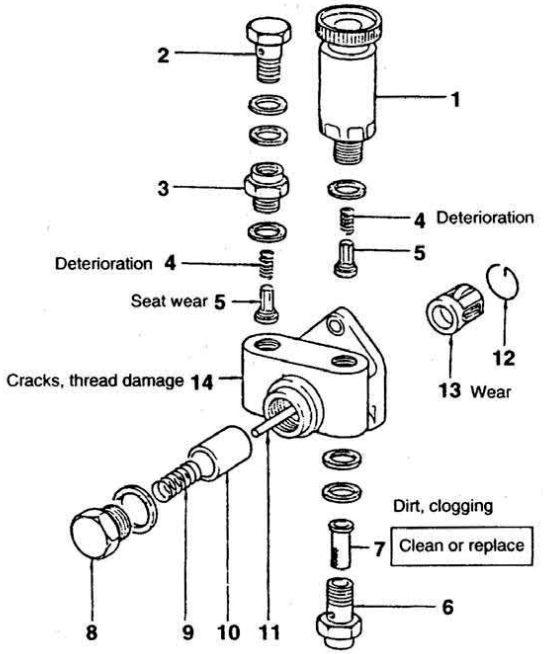
Ensure that the engine does not stall or hunting does not occur even when the adjusting lever is abruptly returned from the full load to idling position. If any unusal condition is present, adjust within the specification range.



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5-5. Feed Pump

5-5-1. Disassembly, Inspection and Reassembly



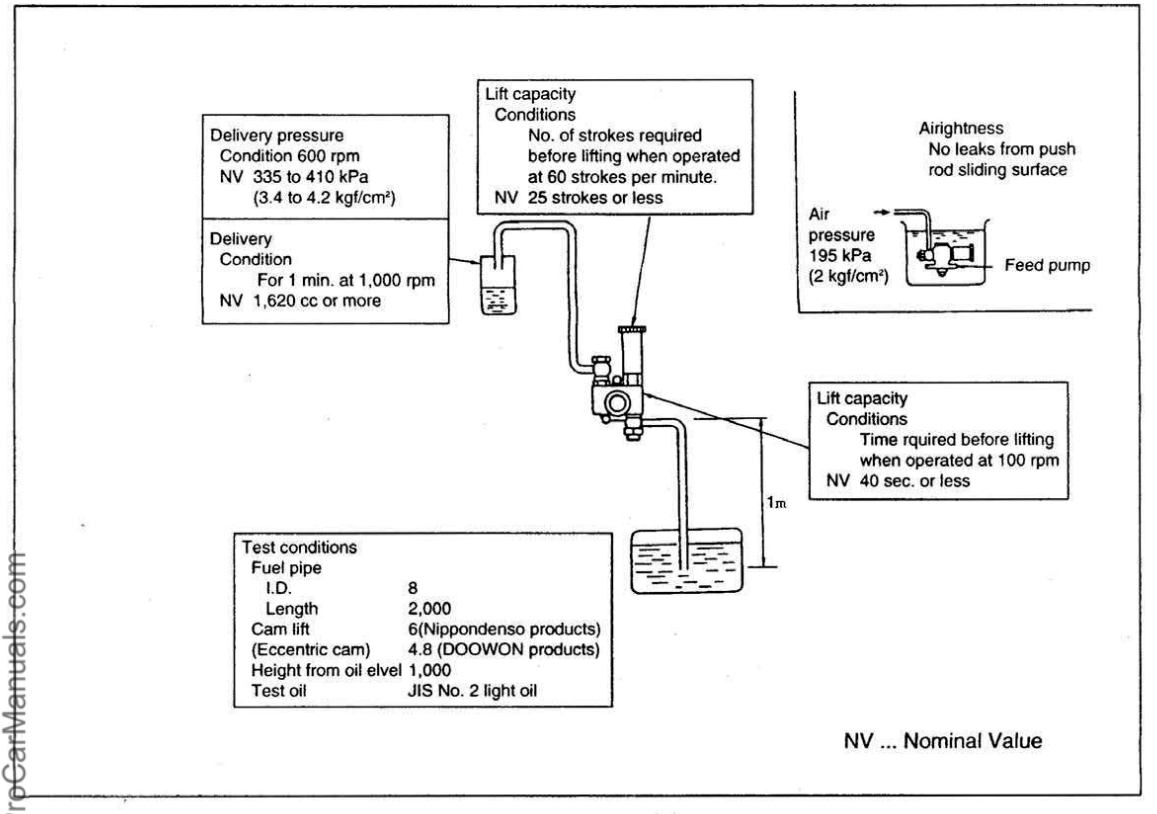
<Diassembly sequence>

1 Priming pump
2 Eye bolt
3 Valve support
4 Spring
5 Check valve
6 Eye bolt
7 Gauze filter
8 Plug
9 Spring
10 Piston
11 Push rod
12 Snap ring
13 Tappet
14 Housing

For reassembly, reverse the order of disassembly.

NOTE: Know the trouble spots thoroughly by making tests before disassembly.

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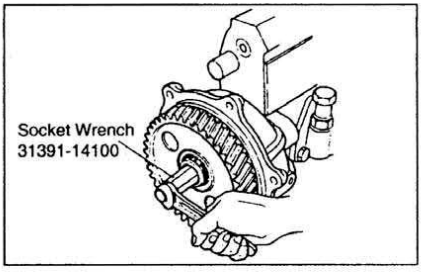
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5-6. Automatic Timer

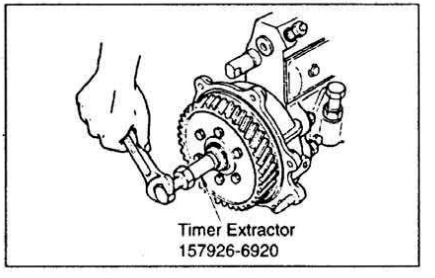
5-6-1. SCDM Type Automatic Timer

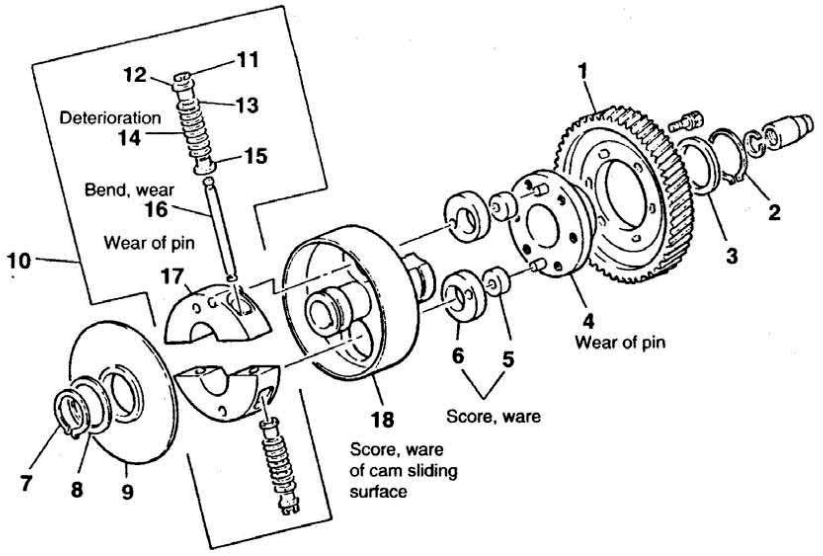
(1) Removal

(a) Using Socket Wrench(special tool), loosen the roundnut.



(b) Using Timer Extractor(special tool), remove the auto timer from the injection pump.



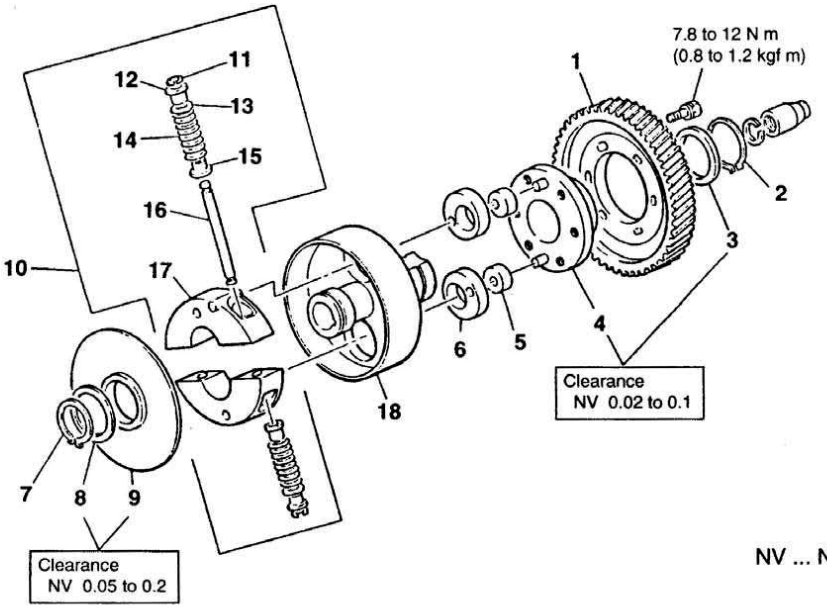


<Disassembly sequence>

1 Injection pump gear
2 Snap ring
3 Shim
4 Flange
5 Smaller cam
6 Larger cam
7 Snap ring
8 Shim
9 Cover
10 Flyweight assembly
11 Snap ring
12 Outer spring seat
13 Shim
14 Spring
15 Inner spring seat
16 Pilot pin
17 Flyweight
18 Timing flange

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5-6-3. Reassembly

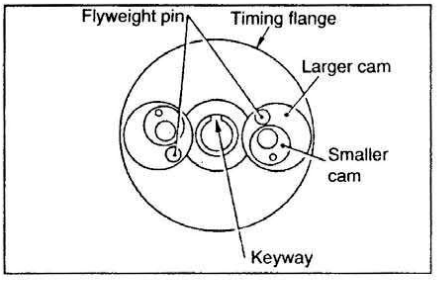


<Assembly sequence>

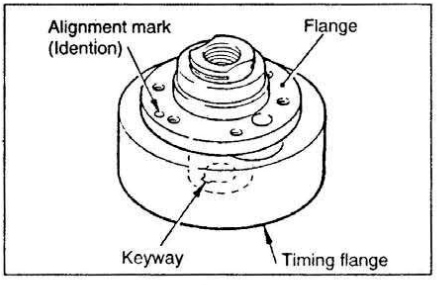
18
17→16→15→14→13→12→11→⑩→⑥→⑤→
→④→3→2→1→⑨→8→7

For reassembly of parts with an encircled number, see following items.

(a) After the flyweight assembly has been installed to the timing flange, position the flyweight pins as shown, with reference to the keyway in the timing flange, and install the larger and smaller cams.



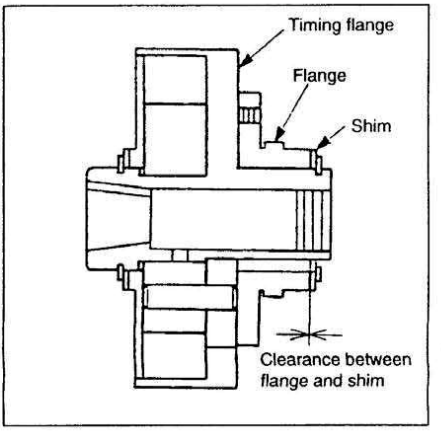
(b) Install the flange, aligning it with the hole in the smaller cam and ensuring that its alignment mark(identation) is positioned on the same side as the timing flange keyway.



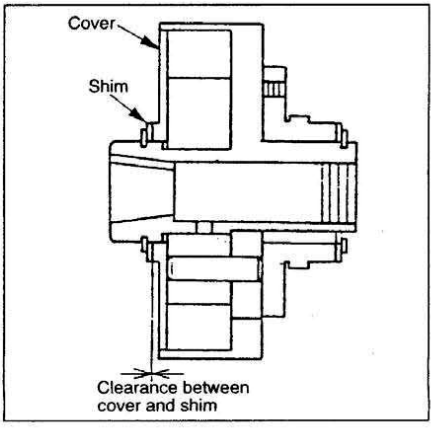
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(c) Put the timing flange and flange closely tied together and ensure that the clearance between the flange and shim is up to specification. If the clearance is out of specification, replace shim.

Shim Thickness
0.10, 0.12, 0.14, 0.16, 0.18, 0.9,
1.1, 1.3, 1.5, and 1.7mm

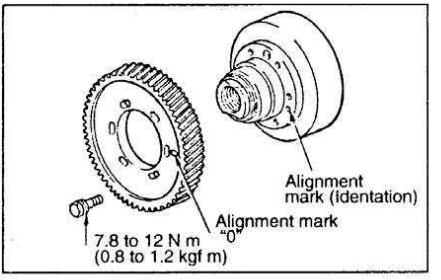


(d) Vary shim to obtain the specified clearance between the cover and shim
Shim Thickness
0.10, 0.12, 0.14, 0.16, 0.18, 0.9, 1.1, 1.3, 1.5, 1.7mm
NOTE:
When measuring the clearance, closely contact the cover and flyweight.
After adjustment, install snap ring.



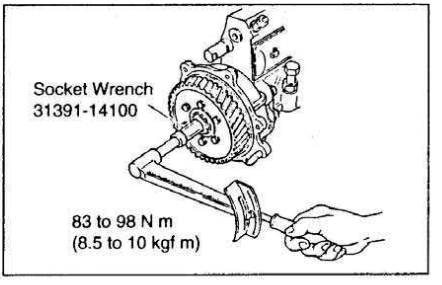
(e) After the timer characteristic adjustments have been completed(see next items), install the gear with its alignment mark "0" lined up with the timing flange keyway or alignment mark on the flange.

Then tighten six bolts diagonally to the specified torque.



1. Installation

Mount the auto timer onto the camshaft, aligning it with the camshaft key. Using Socket Wrench(special tool), tighten the round nut to specification.



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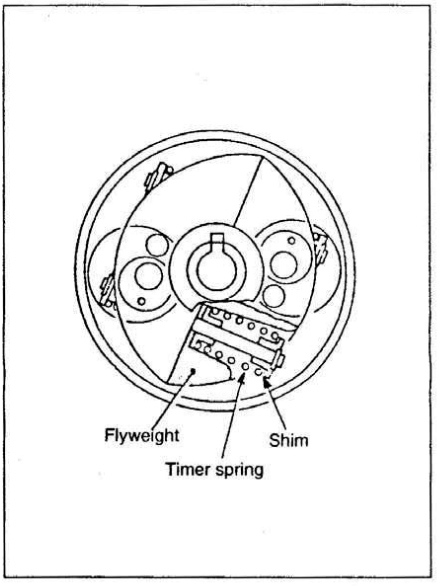
2. Test and Adjustment

Whenever the auto timer has been disassembled, its advance angle must be measured and adjusted with the manufacturer's measuring device.

To adjust the advance charcteristice of the auto timer, add or reduce the adjusting shims or replace the spring.

To reduce the advance angle, increase the shim thickness.

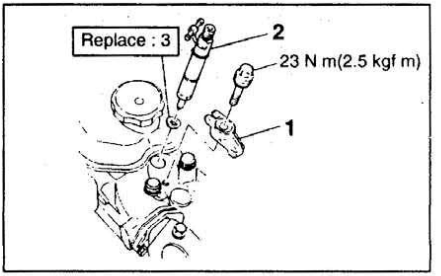
Shim Thickness
0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0,7, 0.8, 0.9, 1.0mm



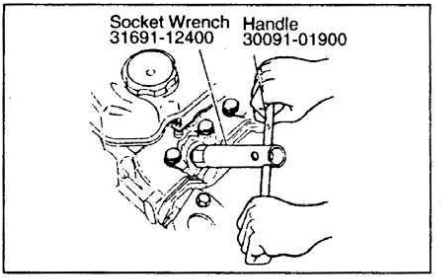
5-7. Injection Nozzle

5-7-1. Removal and Installation

1 Bridge
2 Injection nozzle
3 Nozzle tip gasket



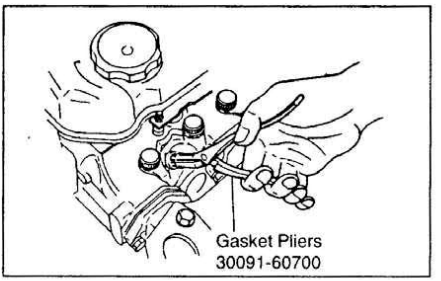
(a) To remove and reinstall the injection nozzle, use Socket Wrench and Handle(special tools).



(b) If the nozzle tip gasket is hard to remove because of seizure, use Gasket Pliers(special tool).

NOTE:

Cover pipes, injection nozzle, and injection pump to prevent entry of dust and dirt. If the injection nozzle is removed, provide adequate means to prevent entry of dust into the cylinder.

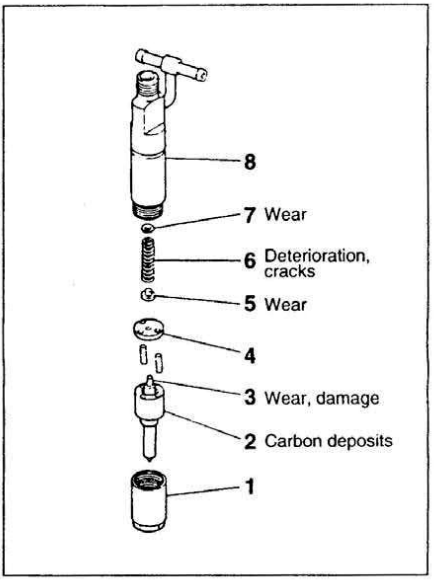


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5-7-2. Disassembly

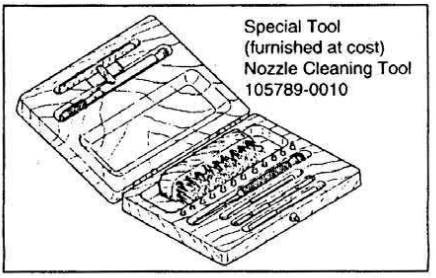
<Disassembly sequence>
1 Retaining nut
2 Nozzle
3 Needle valve
4 Packing
5 Pressure pin
6 Spring
7 Washer
8 Nozzle holder

NOTE:
Make sure that the combination of the nozzle and needle valve is not changed.

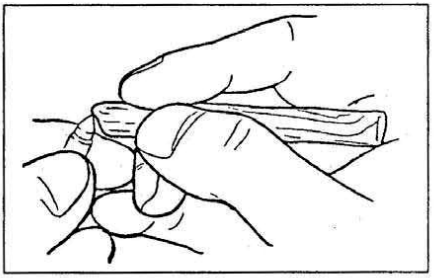


5-7-3. Cleaning and Inspection

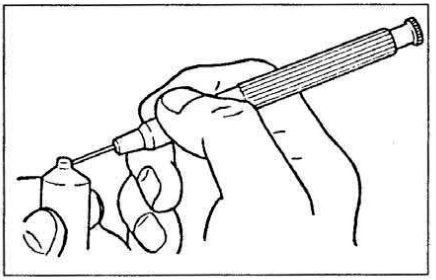
(1) Cleaning
After cleaning the nozzle with gas oil, remove carbon deposits with Nozzle Cleaning Tool(special tool).
Proceed as follow.



(a) Remove the needle valve from the nozzle and clean the needle valve with the needle valve cleaning wood piece.

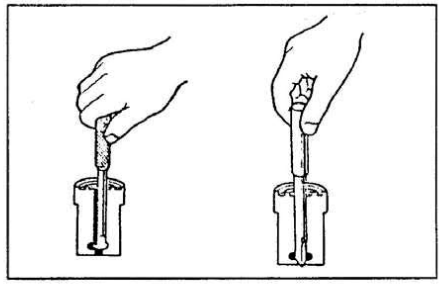


(b) Insert, while turning, a cleaning needle into the injection orifice of the nozzle to remove carbon.
Use first a cleaning needle having smaller diameter than that of injection hole and then finish with following:
0.28mm[Valve opening pressure 17.7 MPa(180 kgf/cm²)]
0.30mm[Valve opening pressure 21.6 MPa(220 kgf/cm²)]



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(c) Remove carbon from the oil pool and valve seat of the nozzle body.

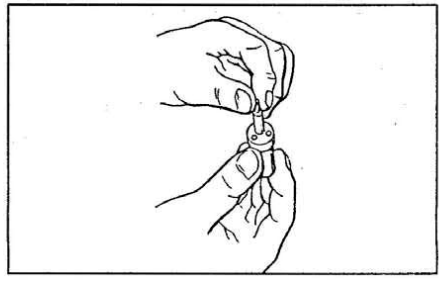


(d) To remove burnt and hardened carbon, use Fuso Carbon Remover.

(2) Inspection

Clean and immerse the nozzle in gas oil, slide the needle valve, and ensure that it moves smoothly.

Next, pull up the needle valve vertically about 1/3 of its entire stroke and check if it falls under its own weight. If it does not fall, replace the nozzle.

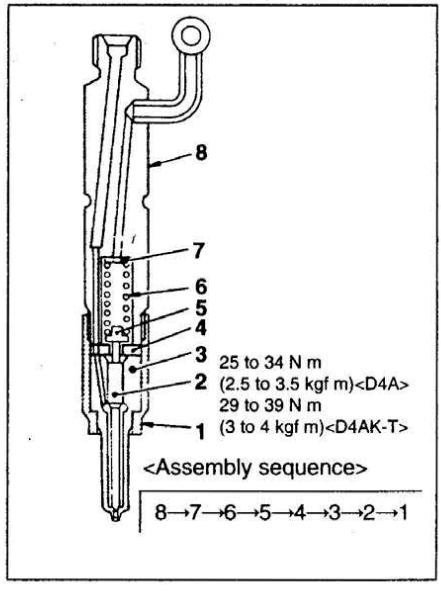


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5-7-4. Reassembly

NOTE:

1. **Never touch the sliding surfaces of the needle valve by hand.**
2. **When replacing the nozzle tip with a new one, remove the seal peel(synthetic resin film) and move the needle valve in nozzle in a clean gas oil to completely remove the anti-rust oil..**



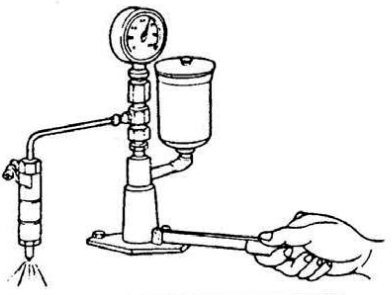
5-7-5. Test and Adjustment

(1) Injection Pressure

(a) Install a nozzle tester to the nozzle.

(b) Operate the nozzle tester to inject several times. This allows the tester to be bled of air.

(c) Operate the nozzle tester at the specified speed. Then, vary shims to obtain the specified injection pressure.



Injection pressure
(Operate lever once per second)
NV 17.7 to 18.6 MPa <D4AN>
(180 to 190 kgf/cm²)
21.6 to 22.6 MPa <D4AK-T>
(220 to 230 kgf/cm²)

NV ... Nominal Value

Shim Thickness

<D4A>
0.95 to 1.25mm in 0.05 increments
1.275 to 1.775mm in 0.025 increments
1.80 to 2.15mm in 0.05 increments

A 0.05mm variation in shim thickness varies the injection pressure by 0.49 MPa(5kgf/cm²).

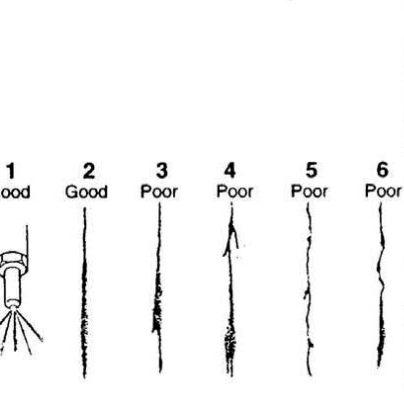
(d) With a correct shim selected, recheck the injection pressure.

NOTE:
Never let yourself exposed directly to the atomized fuel injected from the nozzle.

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(2) Spray Condition

When adjusting the pressure with a nozzle tester, check also for clogged injection orifices, spray condition, and fuel leaks from the orifices. Replace the nozzle if dfective.

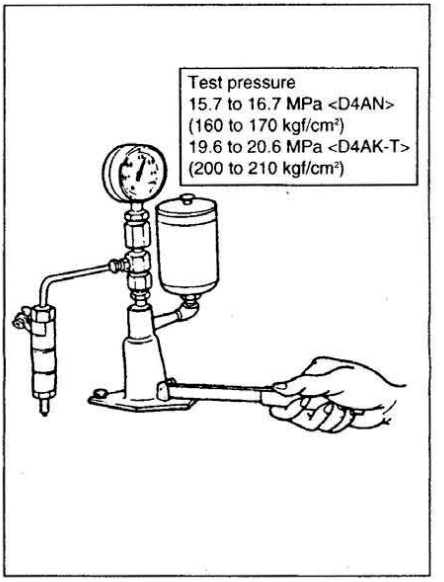


Good
1 Evenly sprayed from five injection orifices
2 Even and symmetrical

Poor
3 Asymmetrical
4 Branched
5 Thin
6 Irregular

(3) Fuel Tightness Test

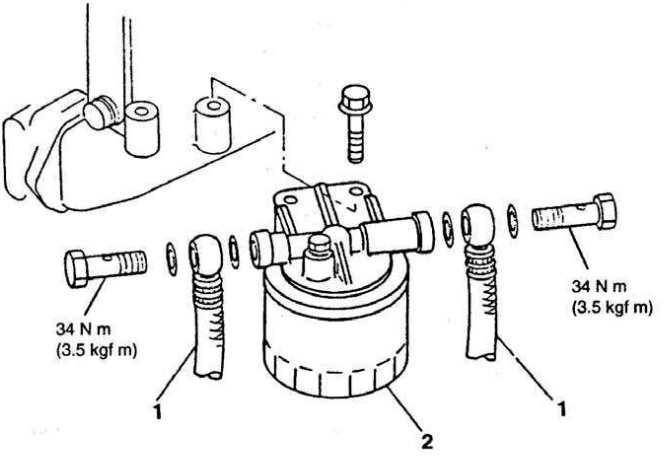
Mount a nozzle, that has been adjusted to start injection at the specified pressure, to the nozzle tester and slowly increase the pressure to the test pressure. Keeping this condition, check for fuel leaks from the bottom of the nozzle. The nozzle is in good condition if there is no leak.



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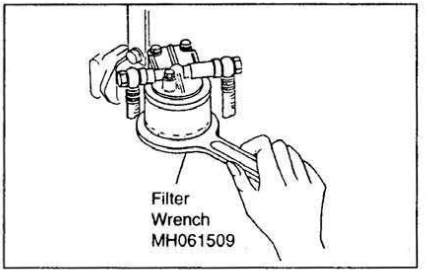
5-8. Fuel Filter

5-8-1. Removal and Installation



1 Fuel feed hose
2 Fuel filter

To remove the element, use Filter Wrench(special tool).

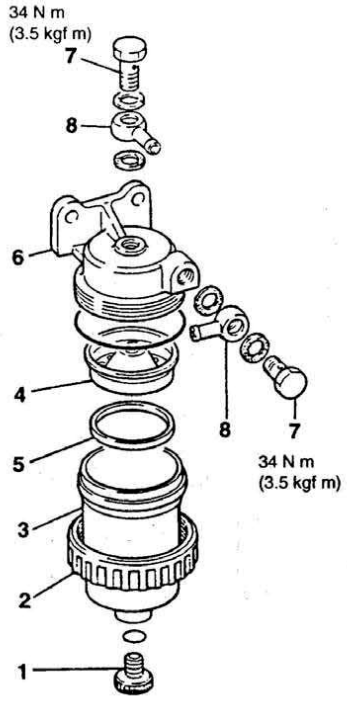


NOTE:

1. **For installation, tighten the element by hands.**
2. **After installation, run the engine and check for fuel leaks.**

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5-9. Water Separator

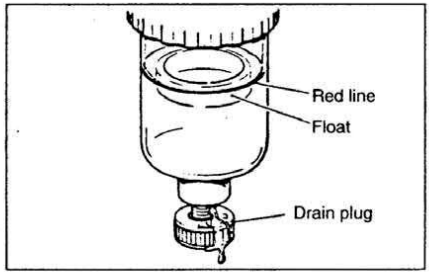


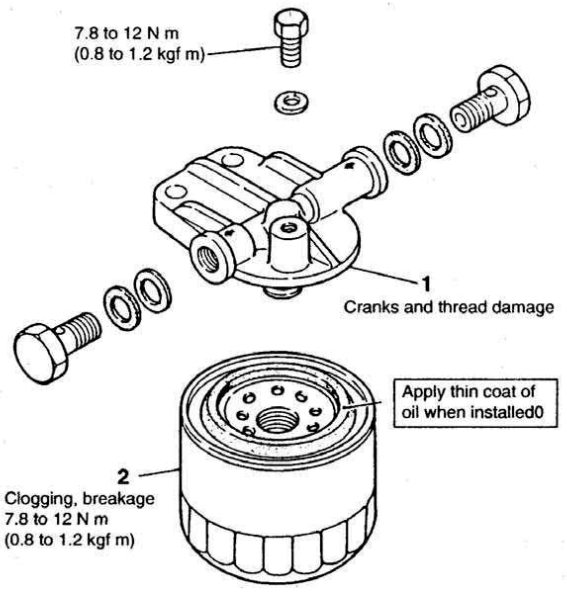
1 Drain plug
2 Ring nut
3 Case
4 Baffle plate
5 Float
6 Head
7 Connector bolt
8 Joint

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If the red float in the translucent case rises to the level of the red line marked on the outer circumference of the case, loosen the drain plug to discharge water.
It is not necessary to completely remove the drain plug as water is discharged gradually through the groove of the loosened plug.

NOTE : After draining, tighten firmly the drain plug before bleeding the fuel system.



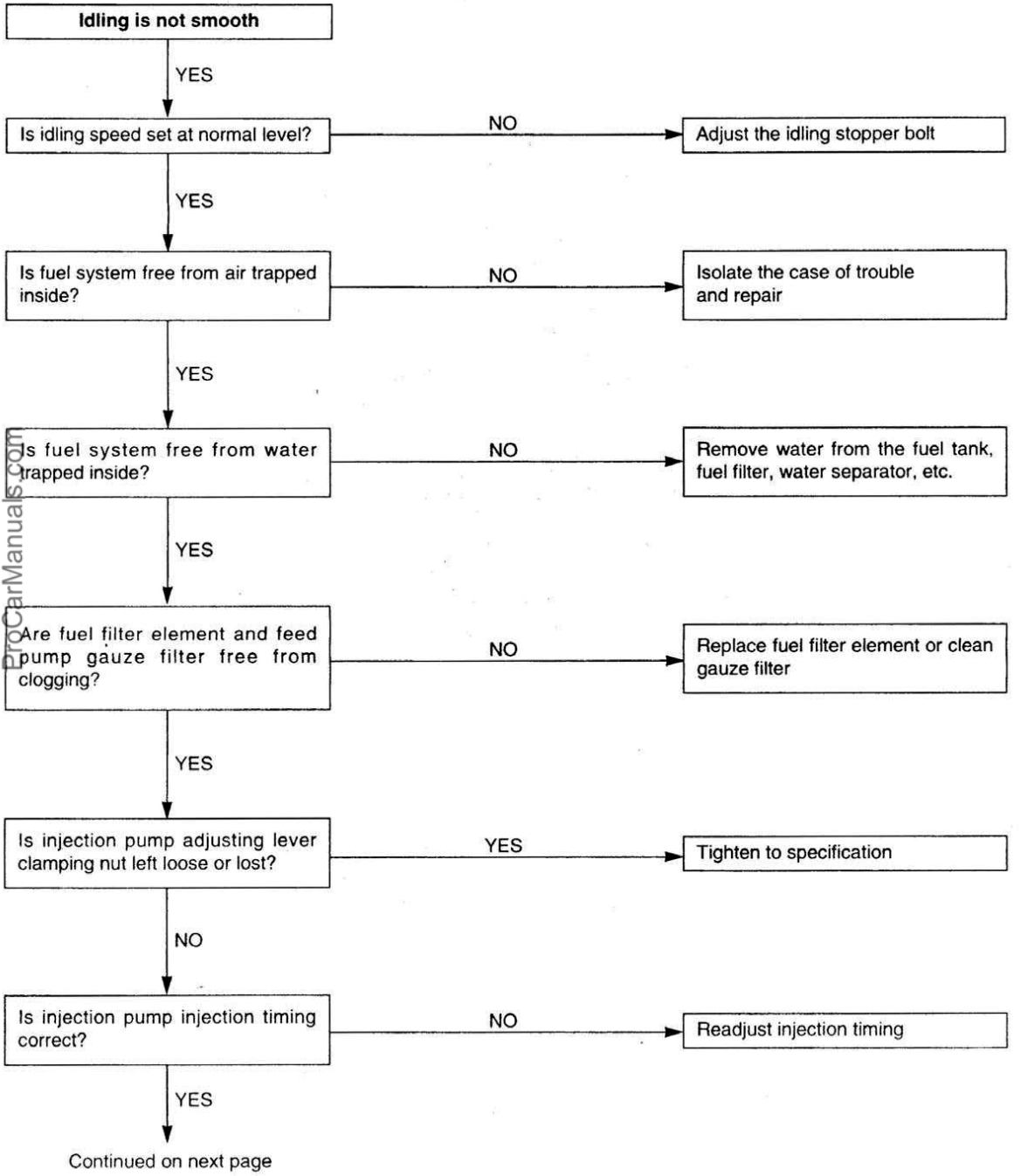


1 Fuel filter head
2 Element

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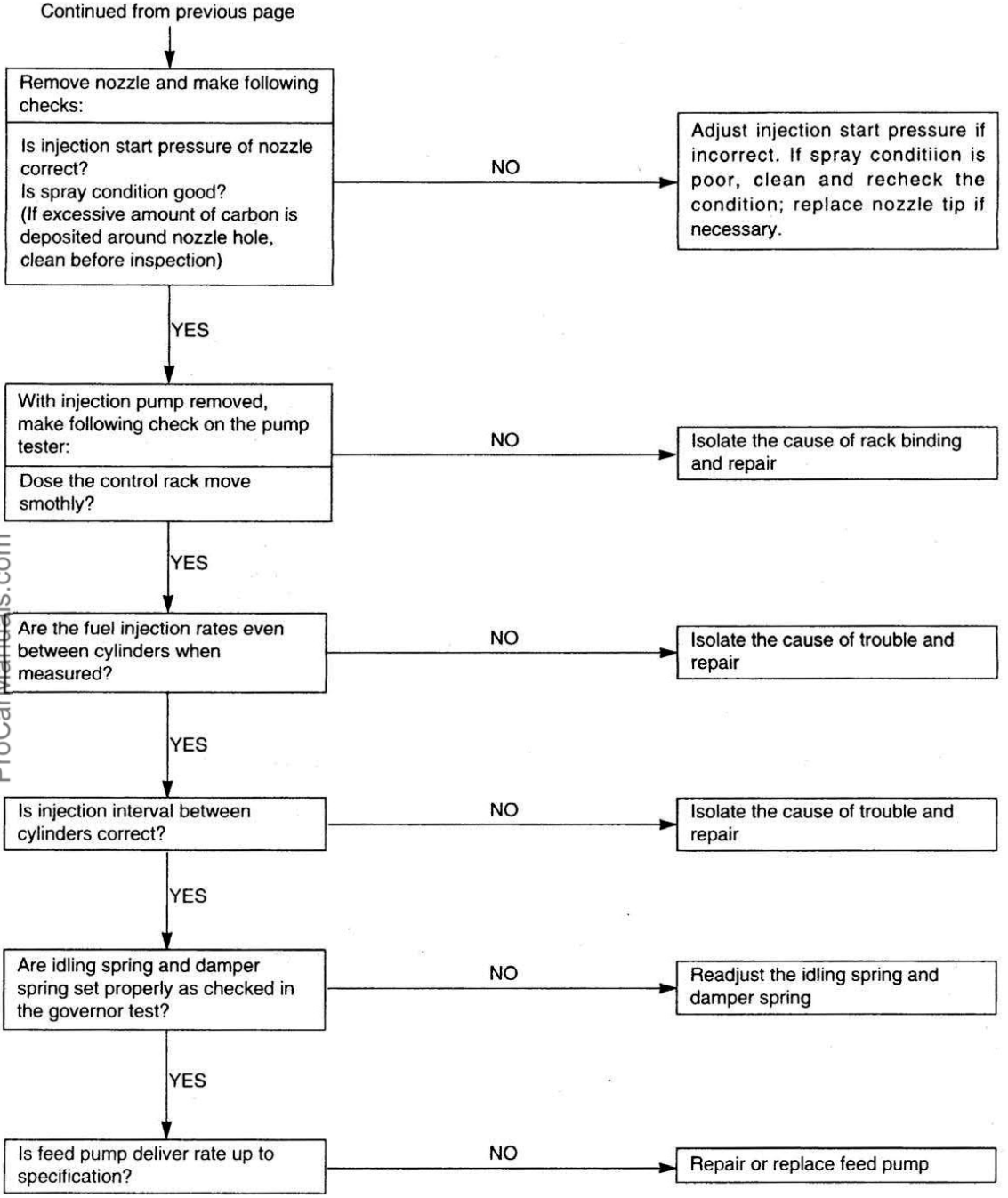
6. TROUBLESHOOTING

(1) Fuel Injection Pump

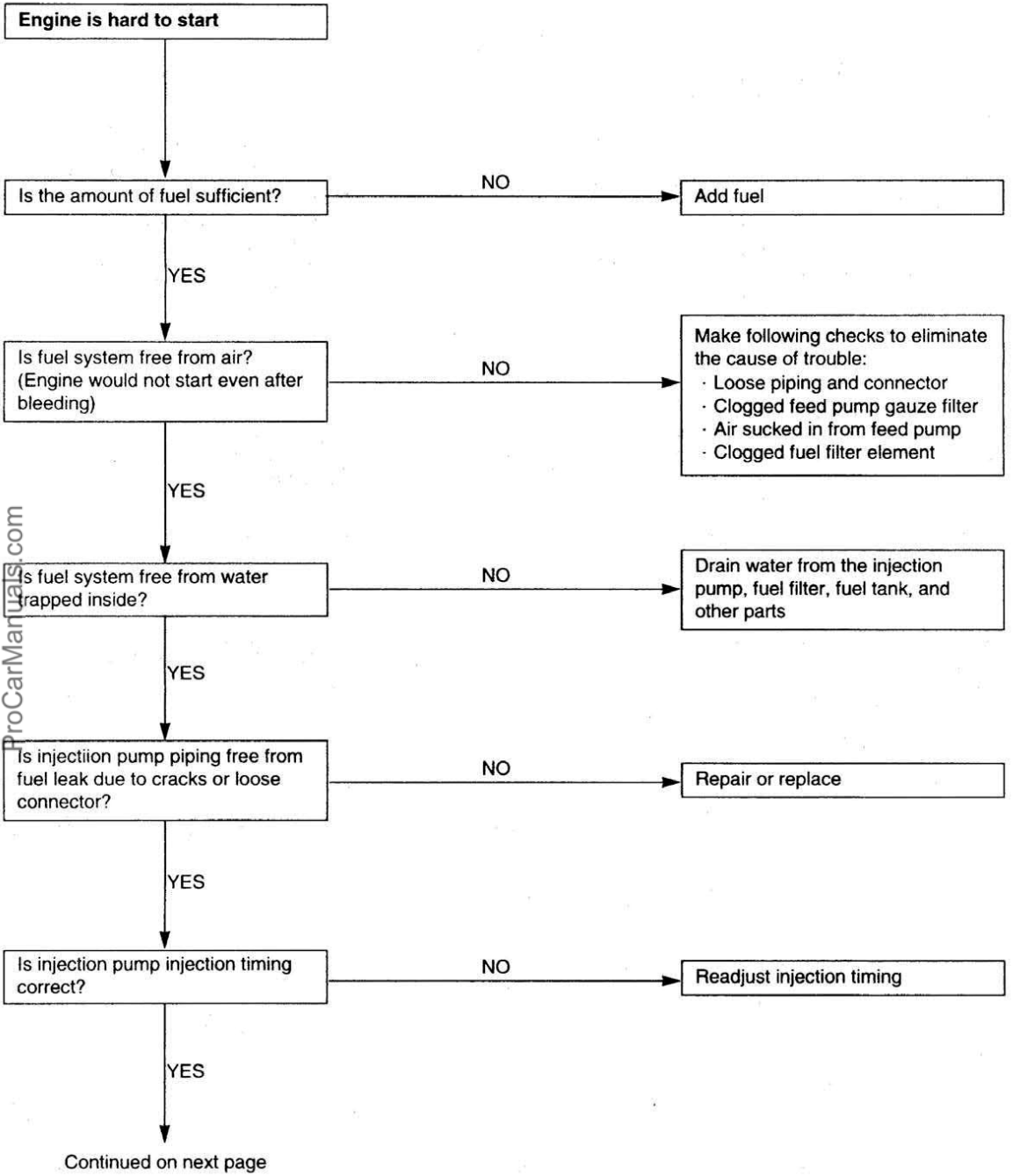


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Remove nozzle and make following checks:

Is injection start pressure of nozzle correct?
Is spray condition good?
(If excessive amount of carbon is deposited around nozzle hole, clean before inspection)

NO → Adjust injection start pressure if incorrect. If spray conditiion is poor, clean and recheck the condition; replace nozzle tip if necessary.

YES

With injection pump removed, make following check on the pump tester:

Dose the control rack move smoothly?

NO → Isolate the cause of rack binding and repair

YES

Are the fuel injection rates between cylinders even?

NO → Isolate the cause of trouble and repair

YES

Is injection interval between cylinders correct?

NO → Isolate the cause of trouble and repair

YES

Are idling spring and damper spring set properly as checked by the governor test?

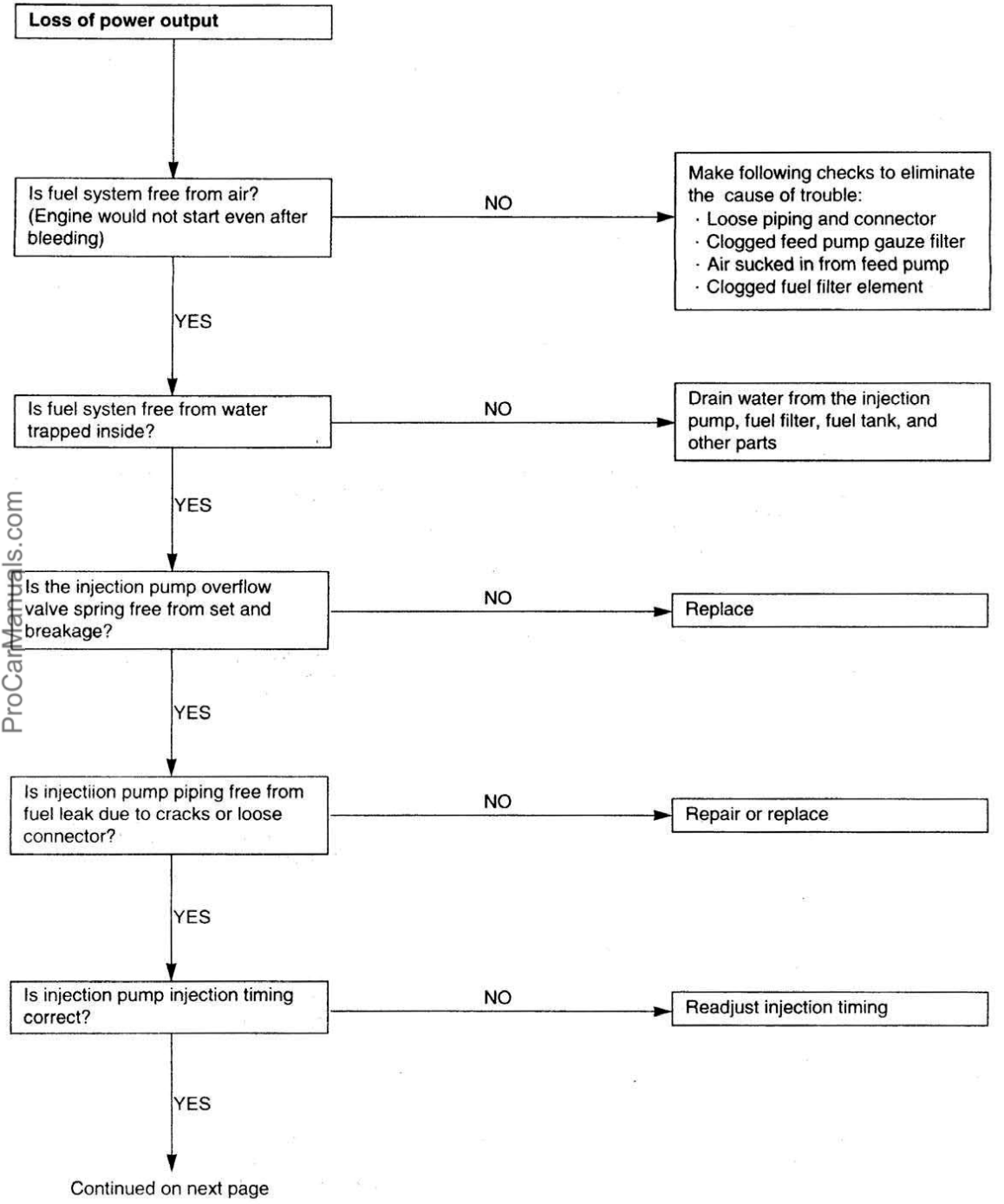
NO → Readjust the idling spring and damper spring

YES

Is feed pump deliver rate up to specification?

NO → Repair or replace feed pump

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Remove nozzle and make following checks:

Is injection start pressure of nozzle correct?
Is spray condition good?
(If excessive amount of carbon is deposited around nozzle hole, clean before inspection)

NO → Adjust injection start pressure if incorrect. If spray conditiion is poor, clean and recheck the condition; replace nozzle tip if necessary.

YES

With injection pump removed, make following check on the pump tester:

Dose the control rack move smoothly?

NO → Isolate the cause of rack binding rack and repair

YES

Are fuel injection rates between cylinders even?

NO → Isolate the cause of trouble and repair

YES

Is injection interval between cylinders correct?

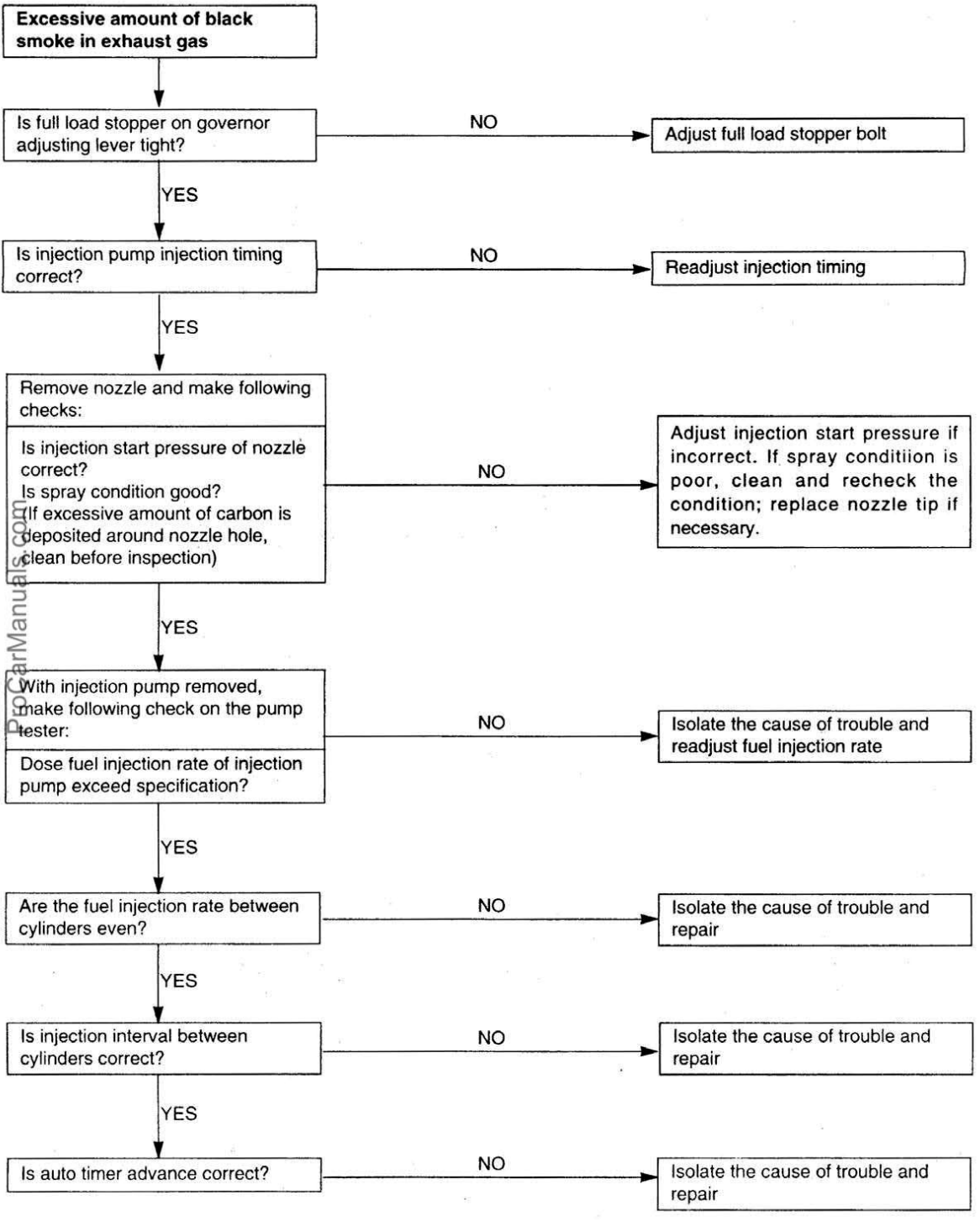
NO → Isolate the cause of trouble and repair

YES

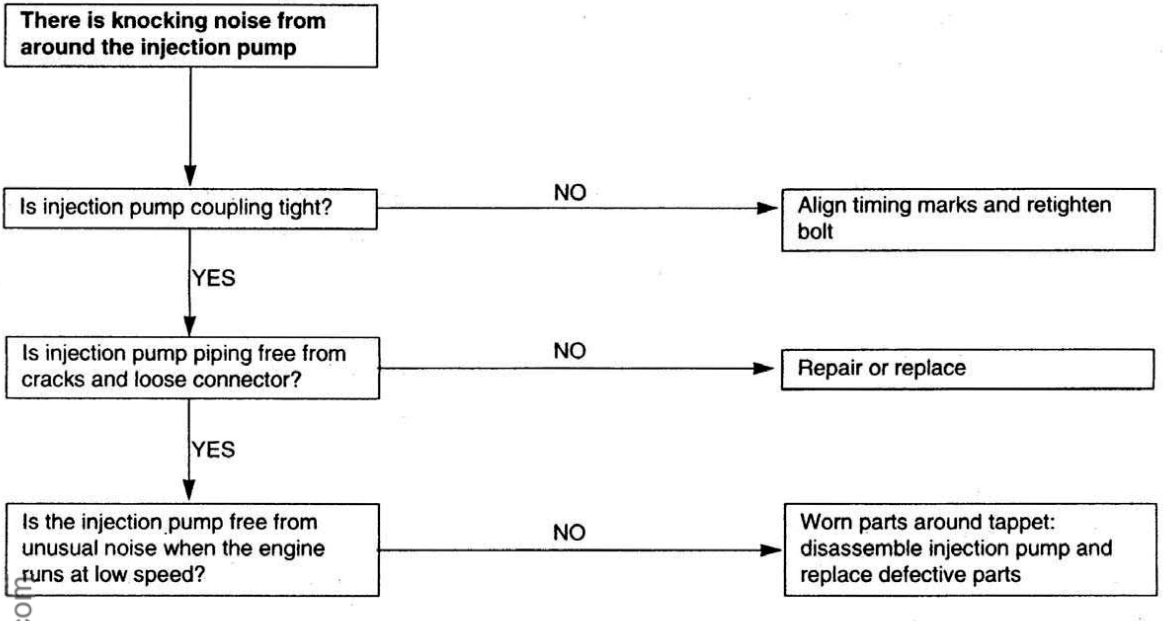
Is auto timer advance correct?

NO → Isolate the cause of trouble and repair

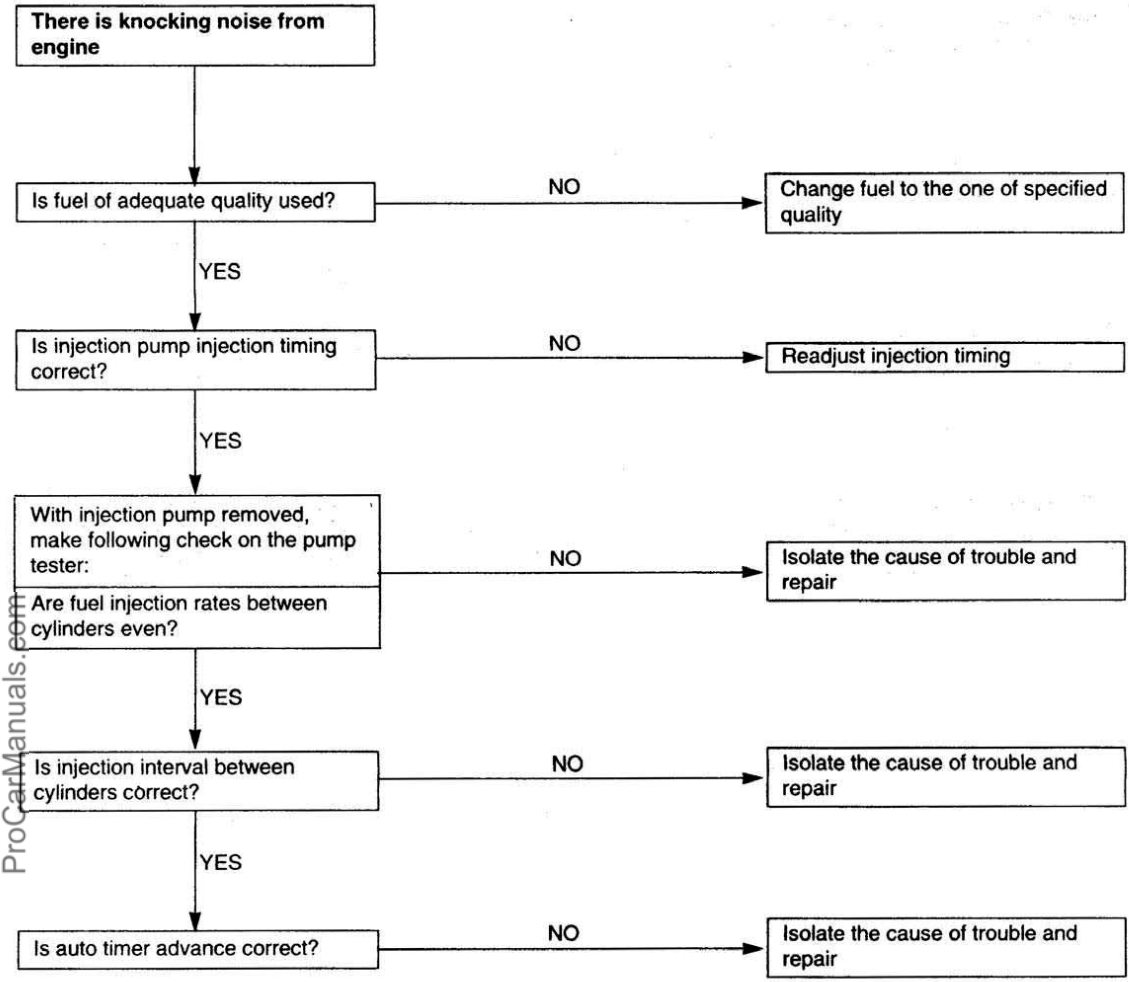
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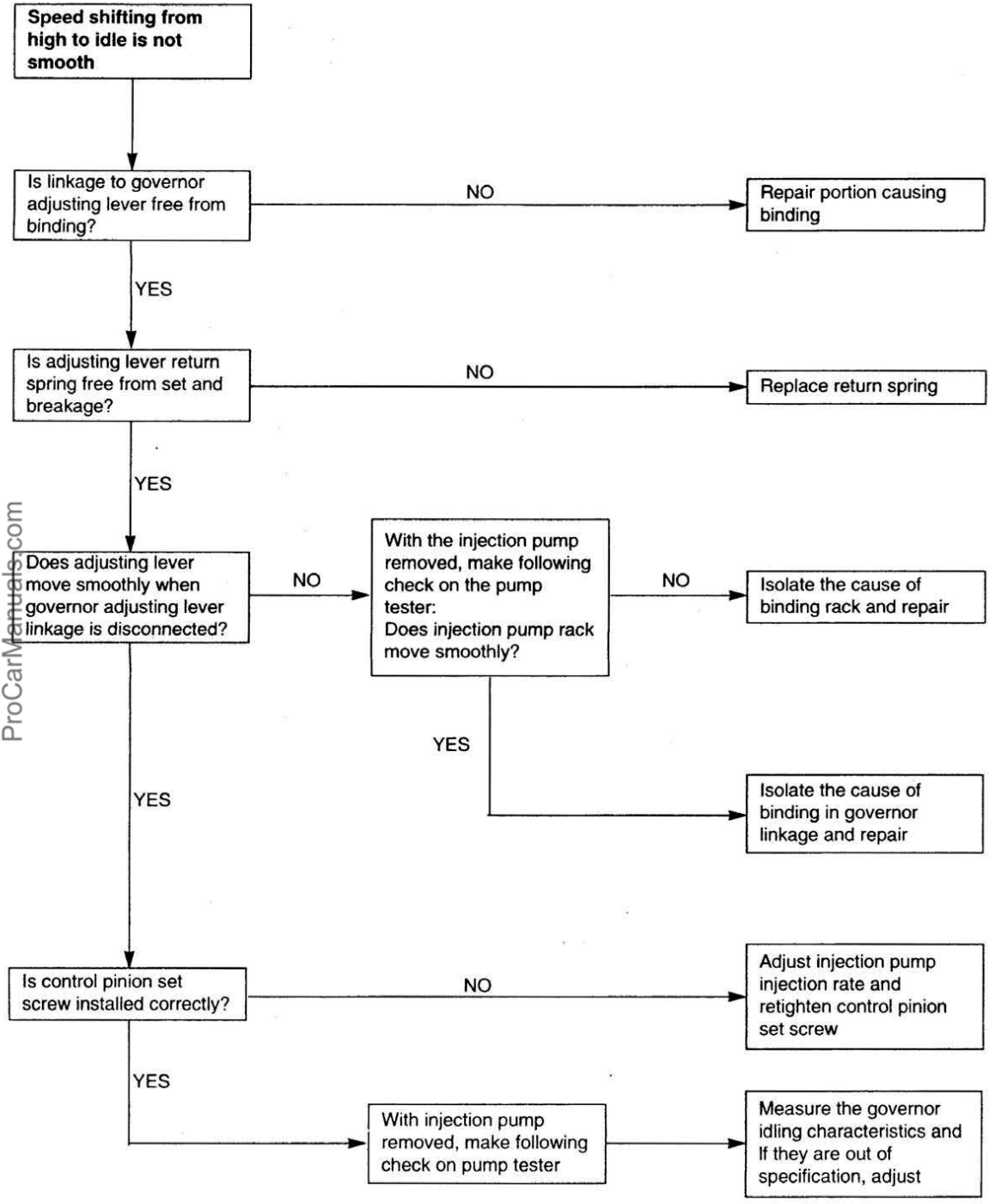
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